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EDWIN DUNKIN, F.R.S., President, in the Chair.

Rev. Thomas Perkins, M.A., The School, Shaftesbury, Dorset, was balloted for and duly elected a Fellow of the Society.

On some Points of Difference between the Harvard and Oxford Stellar Photometry. No. 1. By Prof. C. Pritchard., D.D., F.R.S.

The second part of the *Harvard Photometry* recently published contains, among many other subjects of interest, a very elaborate series of comparisons of the magnitudes of stars as estimated or measured by a great variety of astronomers. Among these is a comparison between the photometric measures made at Harvard with the Meridian Photometer and those made with the Wedge Photometer at Oxford. Such comparisons of catalogues may possess a very great scientific value.

In the course of the above inquiry, and as one result of the comparison referred to, the following passage occurs:* "The results derived from the Wedge Photometer should theoretically be affected by the brightness of the background, and this effect appears actually to occur in the present instance," *i.e.* in the catalogue of photometric magnitudes published in vol. xlvii. of the *Memoirs* of the R.A.S., but which, it is important to observe, forms but a small part of the completed work.

I confess that these statements greatly surprised me, because from the very first application of the method to its final completion I had watched the progress of the work with a scrupulous and jealous care, lest some systematic error might after all lurk either in the principles of the instrument or in the mode of its use. In particular I had considered any possible effects arising

* *Harvard Photometry* ("Annals of Harvard College Observatory," vol. xiv.), p. 493.

from the varying brightness of the background against which the stars were apparently projected, and specially I felt it necessary to be *practically* assured (irrespective of any theory) that even bright Moon light, or the total absence of the Moon from the sky, produced no sensible effects on the determination of relative magnitude. If such be the case (as it in reality is) with bright Moon light, then the slighter variations of the background arising from variations in stellar density (the form in which the objection is made) might reasonably be expected, *a fortiori*, to be harmless. Nevertheless, I have also *practically* assured myself that such is the case as to the observations themselves.

First, with regard to the effects of Moon light on the point of extinction of any particular star. During the three years through which the observations extend, *Polaris* has been extinguished many thousand times. Accordingly I have divided these extinctions into four periods, corresponding to the four phases of the Moon, and, as a result, I find that whatever may have been the phase, the mean point of wedge-extinction of *Polaris* remains sensibly the same. This will be rendered evident by an inspection of the following table.

Point of Wedge-Extinction of Polaris in reference to the Moon's age.

Moon's Age.	Mean Wedge reading for Extinction.	No. of Extinctions.
d d	inches	
0– 7	4·77	1050
7–14	4·76	1125
14–21	4·74	1675
21–28	4·75	1275

In the foregoing table, column one gives the Moon's quarterly phase, during which the extinctions were made. The second column gives the mean reading in inches, measured from the extremity of the wedge, of the point of extinction. The last column gives the number of extinctions employed in obtaining the mean. The observations in question were made with one wedge applied to a telescope of 4 inches aperture. Similar observations in number and principle were also made with an aperture of 2 inches; and again, with another wedge and another telescope of 3 inches and $1\frac{1}{2}$ inch aperture. It is only necessary to add that a variation of one-hundredth of an inch in the wedge reading, implies a variation of one-fiftieth of a magnitude.

I come next to the less salient case of a varying brightness of the field, arising from varying stellar density in different portions of the sky, and the question here arises, "Is it a fact that the Oxford results depend, to any extent, on the brightness of the field" * as arising from this cause? The implication here made is, after all, indefinite in amount, and possibly necessarily

* *Harvard Photometry*, p. 502.

so, owing to the extremely small number of measures then published in some of the groups. Be this as it may, in the *Harvard Photometry* the heavens are divided into thirty-six portions of approximately equal area, and the corresponding stellar densities in each of these are tabulated as obtainable both from the *Harvard Photometry* and the more extended tables of the *Durchmusterung*. The results of the *Harvard Photometry* are then practically assumed as a Standard, and the mean deviations of the Oxford results from the Harvard results in each of the thirty-six divisions are tabulated,* and then, as a final result, the conclusion given above is drawn.

The three densest portions of the sky are designated as B_8, C_3, C_{10}; that is approximately the regions of *Cygnus*, *Taurus* and *Orion*, and *Aquila* respectively. If, then, the systematic error attributed exists, we should expect to find it most pronounced by deviation from the Standard in these regions; but in point of fact the deviations from the Standard in the region B_8 stand, not first, but fourth, in numerical order; and in the other two, C_3 and C_{10}, the deviations from the assumed Standard are inconspicuous and singularly small. On the other hand, where the deviations from the Harvard Standard are most pronounced, viz. in D_5, D_3, C_4 (viz. in *Hydra*, *Monoceros*, and *Canis Minor*), the sky is in D_5 and C_4 below the average of brightness; the region D_3 is slightly above the average stellar density. From this investigation I cannot avoid the conclusion that there is no sufficient ground (from the data published) for suggesting the existence of a systematic error in the *Oxford Photometry* from the cause referred to. On an examination of the *whole* Oxford Catalogue, now on the eve of publication, and containing a large number of the fainter stars, where the effect would be greatest (if any), I find still stronger grounds for denying the existence of any such small systematic error as the one referred to.

Lastly, in the *Harvard Photometry* a systematic error is suggested as existing *generally* in catalogues of magnitude, depending upon the magnitude of the stars. I cannot say whether the Oxford measures are included in this suggestion or not. That it does exist in estimations made by the unaided eye is, I think, very probable; and, in fact, it was long ago suggested as natural and even proper by Sir John Herschel, but upon a very elaborate examination of the 3,000 stars contained in my completed catalogue, I have found not the slightest trace of any systematic deviation of measure, when compared with the Harvard Catalogue, due to the brightness of the objects measured.

As a final result of these investigations I claim on behalf of the wedge photometer that no systematic error exists, either in relation to the varying brightness of the field of view or to the brightness of the stars themselves.

It will be remarked that the inquiry as to the influence of

* *Harvard Photometry*, p. 490.

variable stellar density on the Oxford Photometry, depends solely on a comparison of the Oxford work with the Harvard Catalogue, taken as the Standard of reference. It appears, therefore, to me to be a matter of scientific importance herein, to institute some investigation regarding the amount of reliance which is to be placed on the accuracy of the magnitudes assigned to single stars in the Standard itself; and this investigation can be made alone by means supplied in the published volume. Now, by far the greater number of the Harvard adopted magnitudes is derived from the mean of separate determinations made on *three* different nights. The residuals of these three determinations from the adopted mean magnitude are given in the General Catalogue, Table xxvii. That these three residuals inadequately express the amount of exactness of the adopted mean magnitude, appears from the following considerations. In many instances a much greater number of measures of magnitude is given, obtained on many different nights, sometimes extending to as many as fifteen or twenty. *Sirius*, *Arcturus*, &c., are instances of this. It is from these numerous measures that we can obtain some indication of the reliance which is to be placed on a determination derived from three only. By way of illustration, a fair criterion of the value of transit observations (simply considered as transits) may be derived by comparing the adopted mean obtained from observations over nine wires, with the results obtainable from those over any three of the wires.

If this sort of test be applied to the *Harvard Photometry*, notable differences in the magnitude of the same star will be found to occur with frequency. The measures derived from *three* successive nights are taken, because it is from the measures of three successive nights alone, that the vast bulk of the magnitudes in the Catalogue is derived, provided only no suspicious circumstances have occurred during the three said successive nights. As an example, and for the sake of clearness, take the observations of *Sirius*, No. 1275, Table xxvii. They are sixteen in number. The adopted magnitude is $-1{\cdot}43$. Now, if the magnitude of *Sirius* had been derived from the third, fourth, and fifth nights of observation alone, it would differ from the finally adopted magnitude by ·33 mag.; and if the measures on the sixth, seventh, and eighth nights only be taken, the magnitude would differ by ·30 *in the other direction*, *i.e.* there would be a difference of six-tenths of a magnitude between the two results, and no suspicious circumstance is recorded as having attracted the attention of the observer, except, perhaps, in the third series. This seems to indicate that great exactness cannot be necessarily conceded to the Meridian Photometer, when observations are limited to three nights only. Further still, there are instances in which a magnitude derivable from even as many as seven successive nights, sensibly differs from the finally adopted magnitude. The measures of ε *Orionis*, *Pollux*, &c., will be found

to support this statement, even among the few stars comprised in the subjoined table.

The following table has been constructed on the principles indicated above, and it applies to all the brighter stars visible in the northern heavens, from *Sirius* down to stars comparable in lustre with *Polaris*.

Variations in the magnitude of the bright stars, from Sirius to Polaris, as derivable from any three successive concluded measures of magnitude in the Harvard Photometry, "H. P."

Star's Name.	Least Mag. of Star in H.P.	Greatest Mag. of Star in H.P.	Diff. of Mag.	Adopted Mean Mag.	No. of Night.
Sirius	−1·76	−1·13	0·63	−1·43	16
Arcturus ...	−0·20	0·36	0·56	0·03	13
Capella ...	0·08	0·31	0·23	0·18	16
Rigel	0·15	0·42	0·27	0·32	15
α Lyræ ...	0·09	0·36	0·27	0·19	15
Procyon ...	0·36	0·76	0·40	0·46	15
α Orionis ...	0·81	1·08	0·27	0·91	10
Aldebaran ...	0·80	1·17	0·37	1·00	16
α Aquilæ ...	0·64	1·14	0·50	0·97	15
Antares ...	0·89	1·23	0·34	1·06	13
Spica	1·06	1·63	0·57	1·23	13
Pollux	0·75	1·39	0·64	1·12	15
Fomalhaut ...	1·09	1·46	0·37	1·26	16
Regulus ...	1·29	1·52	0·23	1·42	15
α Cygni ...	1·20	1·77	0·57	1·47	13
ε Canis Maj. ...	1·22	1·72	0·50	1·49	17
Castor	1·26	1·69	0·43	1·56	15
γ Orionis ...	1·73	2·13	0·40	1·86	16
ε Orionis ...	1·56	1·89	0·33	1·76	16
ζ Orionis ...	1·62	2·12	0·50	1·89	15
β Tauri ...	1·80	2·13	0 33	1·90	15
η Ursæ Maj. ...	1·75	2·12	0·37	2·02	13
λ Scorpii ...	1·48	1·91	0·43	1·68	6
ε Ursæ Maj. ...	1·52	2·02	0·50	1·85	13
α Ursæ Maj. ...	1·86	2·06	0·20	1·96	15

Star's Name.	Least Mag. of Star in H.P.	Greatest Mag. of Star in H.P.	Diff. of Mag.	Adopted Mean Mag.	No. of Nights.
α Persei ...	1·77	2·04	0·27	1·94	19
β Aurigæ ...	1·90	2·37	0·47	2·07	14
δ Canis Maj. ...	1·65	1·98	0·33	1·85	15
θ Centauri ...	1·70	1·86	0·16	1·73	6
α Androm. ...	1·85	2·31	0·46	2·08	16
Polaris ...				2·15	
γ Geminor. ...	1·83	2·10	0·27	2·00	17
β Canis Maj. ...	1·84	2·18	0·34	2·01	15
α Hydræ ...	1·85	2·22	0·37	2·02	15
α Arietis ...	1·91	2·21	0·30	2·04	19
ζ Ursæ Maj. ...	2·18	2·51	0·33	2·38	13

In the above table the second column contains the least magnitude of the particular star, as derived from any three consecutive residuals and the finally adopted magnitude given in the general catalogue of the *Harvard Photometry*. The third column is the greatest magnitude derived in a similar manner. The fourth column contains the range of magnitude deduced from the foregoing consecutive combinations. The fifth column contains the magnitude ultimately adopted, and the sixth the number of nights on which the successive measures were made.

Some explanation of the serious discrepancies thus disclosed by the preceding table, and beyond my own power now to give, seems very desirable.

In a short time from the present date the whole of the Oxford work will be published by the University, under the title of *Uranometria Nova Oxoniensis*; and it will then be my duty to compare its results with any other catalogues of a similar nature. At present, one further remark alone remains to be made. Whatever may be the criticisms to which the particular works completed at Harvard College and at Oxford may be fairly open, one thing appears to be certain—namely, that the application of Photometry to the determination of stellar lustre has made an enormous advance over the ancient methods of estimates by the unaided eye. Guided by the experience of some seventy thousand extinctions of stars made with the Wedge Photometer, I feel certain that on any single fair night, the apparent difference of the magnitudes of any two stars may be ascertained within the limits of an error not exceeding the tenth of a magnitude. I conclude with the expression of the hope that no remark made in the course of the present inquiry will be deemed as inconsistent with unfeigned respect for the remarkable ingenuity and unremitting labour which characterise every page of the *Harvard Photometry*.

On Al-Sūfi's Star Magnitudes. By E. B. Knobel.

In vol. xiv. of the "Annals of Harvard College Observatory," Prof. Pickering has drawn attention to some alleged differences between the magnitudes of Ptolemy's stars as given by Al-Sūfi in his "Description of the Constellations," and by Ulugh Beigh in his Catalogue. These discrepancies are given on the authority of Dr. C. H. F. Peters, who has published in the *Astronomische Nachrichten*, xcix. 235, a list of 74 differences which he finds in comparing Schjellerup's translation of Al-Sūfi with Hyde's translation of Ulugh Beigh.

As Prof. Pickering has given a table entitled "Differences between Sūfi* and Ulugh Beg," we might be led to infer that Ulugh Beigh had really made some estimations of star magnitudes, and in that case the question would deserve investigation.

The only information we possess as to the construction of Ulugh Beigh's Catalogue of Stars is contained in his Preface to the Catalogue, which has been translated into Latin by Hyde, and into French by Sédillot, and forms chapter xiii. of the Third Part of his "Prolégomènes des Tables Astronomiques d'Oloug-Beg." The chapter is short, and as Sédillot's work is rather scarce, I beg to transcribe it.

"Avant Ptolémée on avait observé 1022 étoiles fixes; Ptolémée les a placées dans un catalogue inséré dans *l'Almageste.*

"On a distribué ces étoiles en six grandeurs; les plus grandes sont de la première grandeur, et les plus petites de la sixième grandeur.

"On a aussi établi trois ordres dans chaque grandeur, et pour reconnaître les étoiles on a imaginé 48 Figures ou Constellations, dont 21 sont au nord de l'écliptique, 12 dans le zodiaque, et 15 au midi.

"La plupart des étoiles sont dans les figures mêmes; les autres sont aux environs, et on les désigne par le nom d'externes de la constellation.

"Abderrahman Soufi a composé un Traité des étoiles que tous les savants ont reçu avec empressement.

"Avant de determiner par nos propres observations le lieu de ces étoiles nous les avons fait disposer sur des sphères d'après ce Traité et nous les avons trouvées pour la plupart placées différemment qu'on ne le juge à l'inspection du ciel.

"Cela nous a déterminé à les observer nous-mêmes avec le secours de la protection Divine et nous avons réconnu qu'elles étaient avancées en raison de l'époque à laquelle l'ouvrage a été composé, de sorte qu'en leur donnant selon cette observation

* This author is erroneously called "Sūfi" in modern works. His correct name appears to be Abd-al-Rahman Al-Sūfi (pronounced Abdurrahman Assūfi). That is to say, Abd-al-Rahman *the* Sūfi, because he belonged to the old and existing religious sect of the Sūfies. It seems, therefore, incorrect to call him simply Sūfi.

générale, la position absolue qui leur convient, nous n'avons plus trouvé la différence qu'elles présentent à l'œil.

" C'est d'après ce principe que nous avons réobservé toutes les étoiles déjà déterminées à l'exception toutefois de vingt-sept qui ne sont pas visibles à la latitude de Samarcande à cause de son grande éloignement du midi : savoir, les sept de la figure de l'Encensoir (*Ara*), huit dans le Navire de la 36me à la 41me et les 44me et 45me ; onze dans le Centaure depuis la 27me jusqu'à la dernière, et une, la 10me, dans la constellation du Loup ; et nous avons pris ces vingt-sept étoiles dans le livre d'Abderrahman Soufi en tenant compte de la différence de l'époque (de son catalogue et du nôtre).

" En outre il y a huit étoiles dont Abderrahman Soufi fait mention dans son livre comme ayant été placées en leur lieu respectif par Ptolémée, mais que lui Abderrahman n'y a pas vues et que malgré toutes nos récherches nous n'avons pu nous-mêmes découvrir ; c'est pourquoi nous n'indiquons pas ces étoiles dans le présent catalogue : ces étoiles de Ptolémée sont la 14me du Cocher (*Auriga*), la 11me du Loup et les six externes du Poisson Austral.

" Nous établissons dans notre catalogue le lieu des étoiles pour le commencement de l'année 841 de l'Hégire afin qu'en tel temps qu'on voudra on puisse retrouver le lieu de chacune dans la supposition qu'elles avancent d'un degré en 70 années solaires."

As Ulugh Beigh based his catalogue upon that of Al-Sūfi, and makes no mention of any observations of the brightness of the stars, it is not unreasonable to infer that the magnitudes he gives are simply copied from Al-Sūfi, and in that case the alleged " differences between Sūfi and Ulugh Beg " can be nothing more than differences in the MSS., due to transcribers and translators.

It may be mentioned at once that two of the alleged differences are in the case of the 29th and 31st stars in *Centaurus*, which Ulugh Beigh particularly states are not visible at the latitude of Samarcand, and which he therefore copied from Al-Sūfi.

In the *Monthly Notices* for 1879 (vol. xxxix.) I have given a complete translation of the star magnitudes in the Persian MS. of Ulugh Beigh belonging to the Society, and I have shown that this MS., compared with the two editions of Hyde's translation from Oxford MSS., contains 158 different readings. Forty-eight of the supposed differences with Al-Sūfi are here found to have no existence.

Great interest attaches to the description of the constellations and the undoubtedly original estimations of star magnitudes by Al-Sūfi, which makes it worth while investigating all available MSS.

With this object I have examined two Arabic MSS. of Al-Sūfi's " Description of the Constellations," one at the British Musem (Additional MSS. 7488), and the other in the India Office Library (Arabic MS. 2389), which, through the kindness of the Secretary of State, has been lent to me.

Unfortunately, neither of these MSS. is complete. That at the British Museum is of the fifteenth or sixteenth century—well and clearly written, and the drawings of the constellations beautifully executed. The catalogue of the stars in *Equuleus*, *Canis Major*, and the *Informatæ* of *Piscis Australis*, are omitted.

The India Office MS. is probably of a later date. It can be considered only as a fragment, inasmuch as it does not contain the catalogues of *Ophiuchus*, *Serpens*, *Sagitta*, and *Canis Major*, nor the descriptions of *Serpens*, *Sagitta*, and *Aquila*; and the MS. terminates with the description of *Argo*; wanting therefore the catalogue of *Argo*, and the descriptions and catalogues of *Hydra*, *Crater*, *Corvus*, *Centaurus*, *Lupus*, *Ara*, *Corona Australis*, and *Piscis Australis*.

The value of a MS. of Ptolemy or Al-Sūfi depends largely upon the care and accuracy with which the subdivisions of the star magnitudes are indicated. In the Greek *Almagest* these are expressed by the words μείζων and ἐλάσσων appended to the magnitude. In the Latin *Almagest*, translated from the Greek by Trapezuntius, by "ma" (major) and "mi" (minor). In the Liechtenstein Latin *Almagest*, translated from the Arabic by Gerard of Cremona, by "em" (presumably for μείζων) and "el" (ἐλάσσων). In the British Museum Arabic *Almagest* of A.D. 1218, by the Arabic letters mīm م and lām ل. (These two last examples suggest that the original Arabian scribe, who translated from the Greek, had no idea of the meaning or the application of the words μείζων and ἐλασσων, and therefore appended the initials of the Greek words in Arabic letters). In the Bodleian Library Arabic *Almagest* and the several MSS. of Al-Sūfi and Ulugh Beigh, these subdivisions are expressed by the letters Kāf and Sād, being the initials of the words كبير (large) and صغير (small). Thus γ μείζων, 3 ma, 3 em, ج م, ج ك, all express that the magnitude is 3–2.

In the oriental MSS. I have examined, great care has always been taken by the scribes in ruling the necessary columns for entering the catalogues of stars; but in all cases, the last column is ruled only wide enough to insert the number expressing the magnitude, rendering it necessary for the qualifying letters, which indicate that the magnitude is either a large or a small one, to be written in the margin. And as the majority of the magnitudes are without such letters, there is nothing to indicate to the scribe that they are omitted, and so hardly any MS. appears to give the whole series complete.

In the British Museum MS. of Al-Sūfi very many of the initial letters referred to are omitted. From the constellation *Argo* (where there are indications of a change in the writing) to the end of the MS. they are entirely omitted.

In the India Office MS. they are omitted altogether from beginning to end.

Notwithstanding these imperfections, I think it may be interesting to compare the differences between these MSS. and those translated by Schjellerup. I therefore submit a table showing the different readings I have found; and I think that there are enough variations in the MSS. to indicate that we cannot feel sure that we yet possess a sufficiently perfect edition of Al-Sūfi's star magnitudes to warrant the assumption that any differences between him and the Ulugh Beigh MSS. may be due to original observations by the Samarcand astronomer.

In the following table the first column gives Ptolemy's number of the star in the constellation. In the second column the magnitudes in the British Museum and India Office MSS. of Al-Sūfi, indicating the latter by the letters I.O. This MS. being devoid of letters qualifying the magnitudes, I give only those cases which are entirely discordant with the other texts. The third column gives the magnitudes in Schjellerup's *Tableau Synoptique.*

Al-Sūfi's Star Magnitudes.

Differences in the following Arabic MSS.:—
British Museum. Add. MSS. 7488 = Brit. Mus.
India Office MS. 2389 = I.O.
St. Petersburg MS. } examined by Schjellerup = Schj.
Copenhagen MS. }

Constellation	No.	Brit. Mus.	Schj.
Ursa Minor	5	5	5–4
Draco	5	3 3 I.O.	2–3
	10	3 3 I.O.	4
	11	4–5 4 I.O.	3–4
	16	5	5–4
	19	4	4–3
	27	3	3–4
	28	5	5–4
	29	3	3–4
	30	3	3–4
	31	3	3–4
Cepheus	1	4	5–4
	3	4	4–3 3–4
	8	4 5 I.O.	4–3
	11	4 6 I.O.	6

Constellation.	No.	Brit. Mus.	Schj.
Boötes	1	5	5–4
	2	5	5–4
	3	5	5–4
	18	4	4–3
Corona	3	4	4–5
Hercules	13	5	5–6 6–5
	14	5	5–6 6–5
	15	4	4–3
	25	4	4–3
Lyra	2	4	4–3
	3	4	4–3
	4	4	4–3
	5	4	4–5
	6	4	4–5
	7	3	3–4
	8	4	4–5
	10	5	5–6
Cygnus	1	3	3–4
	2	6	6–5

Constellation.	No.	Brit. Mus.	Schj.
Cygnus	4	3	3-2*
	7	4	4-5
	10	4 3 I.O.	3
	11	4	4-5
	12	4 3 I.O.	3
	15	4	4-3
Informatæ	1	4	4-3
Cassiopea	1	4	4-3
	4	3	3-2
	7	4	4-5
	8	4	4-5
	11	4	4-5
Perseus†	3	3	3-4
	4	4	4-5
	12	2	2-3
	13	4	4-5
	14	4	4-3
	25	3	3-4
	26	3	3-4
Informatæ	1	5	5-6
	2	5	5-6
Auriga	10	3	3-4
Ophiuchus	2	3	3-4
	5	4	4-3 3-4
	8	3	3-4
	9	5	5-4
	10	4	4-3
	13	4	4-5 5-4
	14	4	4-5 5-4
	15	4	4-3
	16	4	4-5
	18	5	5-6

Constellation.	No.	Brit. Mus.	Schj.
Serpens	2	4	4-5
	3	3	3-4
	4	3	3-4 3
	6	4	4-5
	7	3	3-4
	8	3	4
	10	3	3-4
	14	4	4-3
	17	4	4-3
Aquila	2	3	3-4
	3	2	2-1
	9	5 3 I.O.	3
Informatæ	1	3	3-4
	3	3	3-4
	4	4	4-5
	6	3	3-4
Delphinus	1	4	4-3
	4	3	3-4
	5	3	3-4
	6	3	3-4
	7	3	3-4
Pegasus	1	2	2-3
	2	2	2-3
	3	2	2-3
	4	2	2-3
	13	5-6 5 I.O.	5-6 6
	14	5-6 5 I.O.	5-6 6

Enumeration in I. O. MS. gives four stars of mag. 3 and four of mag. 5. Schj. gives three of mag. 3 and five of mag. 5.

Andromeda	9	4-5	4-3
	14	4	4-5

* Mag. 3 in Catalogue.

† In Schjellerup's enumeration of the stars there is an error: for "une de la sixième" read "une nébuleuse."

Constellation.	No.	Brit. Mus.	Schj.
Andromeda	17	4	4–3
	18	4	4–3
	21	5–6 5 I.O.	5–6 6–5
	22	5–6 5 I.O.	5–6 6–5
Triangulum	3	5	5–6
	4	3	3–4
Aries	12	5 4 I.O.	5

Enumeration, I. O. MS. gives five of mag. 4 and five of mag. 5. Schj. gives four of mag. 4 and six of mag. 5.

Informatæ	1	3–4	3–2
Taurus	8	4 5 I.O.	4–3
	10	4–3	4
	23	4	5
Informatæ	6	6	6–7
Gemini	7	4–5	4–3
	9	5	5–4
	10	3	3–4
	15	3–2 4 I.O.	4–3
	16	3	3–4
	17	3–2	3
	18	4–5	4

Enumeration, I. O. MS. gives five of mag. 3 and nine of mag. 4. Schj. gives six of mag. 3 and eight of mag. 4.

Gemini Informatæ	1	4–5	4–5 5–4
	4	6 I.O.	5–6
	5	6 I.O.	5–6
	6	6 I.O.	5–6

Enumeration, I. O. MS. gives one of mag. 5 and three of mag. 6. Schj. gives four of mag. 5 and none of mag. 6.

Constellation.	No.	Brit. Mus.	Schj.
Cancer	3	4–5	4–5 5–4
	8	4 5 I.O.	5–6 6–5
	9	4–5	4
Informatæ	1	4	4–5
	2	5	4–5
Leo	3	3	3–4
	4	3	3–2
	13	4	4–3
	19	5	5–4
	23	3	3–4
	24	4	4–3
Informatæ	3	4	4–5
Virgo	11	5	5–6
	14	1	1–2
	15	3	3–4
	16	5	5–6 6–5
	18	5	5–6
	19	5	5–6 6–5
	20	5	5–6
	25	4–5	4
	26	4	4–3
Informatæ	5	6 5 I.O.	5
Libra	2	5–6	5–6 6–5
	4	5–6	5–6 6–5
	5	4–5	4
	6	5	5–6 6–5
Scorpio	4	3–4	3–4 4–3
	7	3	3–4
	16	3	3–4 4–3

Constellation.	No.	Brit. Mus.	Schj.
Scorpio	18	3	3–4
	21	3	3–4
Informatæ	1	4	4–5
Sagittarius	7	4	4–3
	11	4	4–3*
	16	5	5–6
	18	5	5–6
	19	4	4–5
	20	5	5–6
	21	4	4–3
	23	4	4–5
	24	4	4–5
	25	3	3–4
	26	4	4–5
	27	4	4–5

Enumeration, I. O. MS. gives seven of mag. 3 and thirteen of mag. 4. Schj. gives six of mag. 3 and fourteen of mag. 4, not accordant with the magnitudes in the Catalogue.

Capricornus	2	6 I.O.	5–6
	4	6	—†
	11	6 I.O.	4
	14	4	4–5
	15	5	5–4
	16	4	6
	17	4	6
	18	4	5–6
	20	3	4
	21	3	4
	22	3	4–5
	23	3	3–4
	25	4	5–6

Enumeration, I. O. MS. gives seven of mag. 3, four of mag. 5. Schj. gives four of mag. 3 and seven of mag. 5.

Aquarius	1	6	6–7
	2	3	3–4
	4	3	3–4

* Mag. 4 in Catalogue.
‡ Mag. 6 in Catalogue.

Constellation.	No.	Brit. Mus.	Schj.
Aquarius	7	5	5–6
	8	4	4–3
	9	3	3–4
	10	4	4–3
	11	3	3–4
	12	3	3–4
	14	5	5–6
	15	4	4–5
	16	4	4–5 5–4
	17	4	6
	21	5–6 6 I.O.	5–6
	29	5–6	4
	30	5	5–6
Pisces	1	4–5	4
	16	4	4–5
	17	4–5	4
	19	3–4	3–4 4–3
	22	3	3–4 4–3
	25	5	5 4
	26	6	6–7‡
	27	6	6–7‡
	28	6	6–7‡
	31	4	—§
Cetus	16	3	3–4
	19	5	5–6 6–5
	20	5–6	5–6 6–5
Orion	12	5	5–6
	16	5–6	5
	24	3	3–4
	29	3	3–4
	31	3	3–4

† Mag. 6·7 in Catalogue.
§ Mag. 4 in Catalogue.

Constellation.	No.	Brit. Mus.	Schj.
Orion	35	1–2	1
	36	4	4–3
	38	3–2	3–4*
Eridanus	1	4 6 I.O.	4
	3	4–5	4–5 5–4
	12	3–4	3–4 4–3
	17	5–6	5–6 6
	19	4	4–5
	20	4	4–3
	24	5	5–6
	27	4	4–5
	30	4	4–3
	34	4† 1 I.O.	1
Lepus	9	4–5	4–3
	10	4–5	4–3
Argo	3	4	4–3
	5	5	5–6
	6	4	4–3
	10	4	4–5 5–4
	11	5	5–6
	25	4	4–3
	26	4	4–3
	27	3	4
	28	3	4
	29	4	4–5 5–4
	30	4	4–5 5–4
	33	4	4–3
	36	3	4
	41	4	4–3
Argo	42	5	4
	43	3	3–4
	45	3	3–4
Hydra	1	4	4–5
	4	5	4
	5	4	4–3
	8	4	4–5 5–4
	9	4	4–5
	10	4	4–5
	11	6	6–7
	13	5	4
	15	4	4–3
	16	3	3–4
	17	4	4–5
	18	4	3
	21	3	4–3
	22	3	4
	24	3	3–4
	25	4	3–4
Crater	4	5	5–6
	5	4	4–5 5–4
	6	4	4–5
	7	4	4–5
Corvus	1	3	3–4
Centaurus	8	4	4–5
	12	4	4–3
	13	4	4–3
	15	4	4–3
	17	4	4–3
	21	4	5
	25	5	5–4
	28	5	5–6 6–5
	30	omitted	omitted
	33	3	3–4

* Mag. 3 in Catalogue.

† An obvious error. I am not aware of any other instance of *Ultima Fluvii* not being mag. 1.

Constellation.	No.	Brit. Mus.	Schj.	Constellation.	No.	Brit. Mus.	Schj.
Centaurus	36	2	2–1	Ara	3	4	4–3
	37	4	4–5		4	5	5–6 / 6–5
Lupus	3	4	4–3		5	4	4–5
	4	3	4	Cor. Australis	5	5	5–6
	5	4	4–3		8	6	5
	10	4	4–5		9	5	6
	11	omitted	omitted		10	5	6
	12	4	4–5		11	6	5–6
	16	5	5–4		12	5	5–6
	17	6	5–6 / 6–5	Pisc. Australis	6	6	5–6
	18	6	6–7		9	5	5–4
	19	5	5–6		11	3	3–4

1885, *June* 11.

Observations of the Satellites of Saturn and of the Companion of Sirius, made at the U.S. Naval Observatory, Washington. By Professor Asaph Hall, U.S.N.

(*Communicated by Commander A. D. Brown, U.S.N., Superintendent.*)

Conjunction of the Satellites of Saturn.

Mimas.

Date.	Wash. M.T. h m	Position.	Weight.	Remarks.
1884, Sept. 22	15 57·6	S.	3	

Enceladus.

1884, Sept. 22	15 48·6	S.	3	
Oct. 25	13 1·7	S.	2	
1885, Jan. 29	10 22·1	S.	3	
Feb. 16	5 51·7	S.	2	Extremely faint.
18	7 9·8	N.	2	Hazy. Satellite very faint.
20	8 34·1	S.	3	
Mar. 3	7 40·4	S.	3	
14	6 40·7	S.	3	Hazy.

Tethys.

1884, Sept. 23	17 29·7	S.	3	
Nov. 16	12 21·1	N.	3	

Date.	Wash. M.T.	Position.	Weight.	Remarks.
1885, Jan. 8	8 24·9	N.	3	
26	6 46·1	S.	2	Poor images.
Feb. 10	9 11·0	S.	2	Very windy and telescope shaken.
11	7 44·6	N.	3	
12	6 38·0	S.	4	
28	7 42·2	N.	2	Somewhat hazy.
Mar. 17	7 33·8	N.	3	
	Dione.			
1884, Sept. 26	15 57·8	S.	3	Cloudy.
Dec. 16	8 51·2	N.	2	
1885, Jan. 26	9 33·1	N.	2	Poor images.
Feb. 6	8 17·0	N.	3	
17	7 3·7	N.	2	Very unsteady.
	Rhea.			
1885, Jan. 2	8 17·2	S.	3	
29	10 21·1	S.	3	
Feb. 23	6 31·1	N.	3	

Observations of the Companion of Sirius.

Date.	Sid. T.	p	s	Weight.	Remarks.
	h		"		
1885·219	6·6	36·3	7·96	2	Very faint.
·233	6·8	35·2	8·23	2	Faint.
·235	7·0	35·6	8·17	2	Faint.
·252	7·3	36·3	—	2	Very faint; hazy.
·293	8·7	34·4	—	2	Very faint; haze.
·301	8·8	33·9	7·93	4	Double weight.
·304	9·0	33·8	8·22	2	Very faint.
·307	9·1	33·2	7·96	2	Faint.

Mean Results.

	p	s
1885·268	34·73	8″·057

Remarks.—The preceding conjunctions of the satellites of *Saturn* were observed by placing the micrometer wires perpendicular to the major axis of the ring by means of the angle given in the *American Ephemeris* for 1884 and 1885, pp. 465, 479. On March 5, 1885, *Mimas* was seen very distinctly when it was just past north conjunction. This satellite was about two-thirds the distance from the centre of the ball to its edge at $6^h\ 45^m$ M.T.

Mimas was remarkably bright, and could not be missed even when the full light of the planet was admitted to the eye. Generally this satellite is a difficult object, and from the ease with which it is occasionally seen one might think it variable; but I think the difference is due to the quality of the images. On this night the images were excellent for a short time, and *Mimas* and *Enceladus* were seen with ease near conjunction, and the planet and its ring presented a beautiful appearance; but a haze soon covered the sky.

The observation of *Enceladus* on Feb. 18, and of *Tethys* on Feb. 28, were made by A. Hall, jun.

The observations of the companion of *Sirius* were delayed until later than usual. This object was difficult and faint, except on April 19. Double weight has been given to the observation of this date.

1885, *April* 30.

Observations of the Companion of Sirius, made at the Dearborn Observatory, Chicago, U.S.A. By Prof. G. W. Hough.

(*Communicated by the Secretaries.*)

Date.	P.	δ
	°	″
1885·091	32·8	8·01
·140	33·8	7·72
·162	34·2	7·93
·189	33·2	8·01
·206	33·3	8·00
·217	30·9	8·00
·222	32·5	8·07
·241	32·3	7·89
·252	32·3	8·05
·255	32·2	7·94
Mean 1885·197	32·7	7·96

On Daylight Occultations of Aldebaran in 1885. By J. R. Hind, F.R.S.

The following are particulars of two occultations of *Aldebaran* occurring in the present year in daylight. The angles from north point are reckoned as in the *Nautical Almanac*.

1. *Occultation of July* 8–9.

	Disappearance.		Reappearance.	
	h m	°	h m	°
Greenwich	23 24·1	55	0 15·5	317
Edinburgh	23 12·2	70	0 12·8	302
Liverpool	23 16·5	62	0 12·8	311
Dublin	23 12·5	61	0 9·1	311

2. *Occultation of Sept.* 28.

	Disappearance.		Reappearance.	
	h m	°	h m	°
Greenwich	20 33·0	132	21 19·3	234
Edinburgh	20 30·6	147	21 7·2	221
Liverpool	20 30·4	137	21 14·6	230
Dublin	20 27·8	135	21 14·4	232

The above are Greenwich mean times at the respective observatories.

Elliptic Elements of Comet II. 1883 (*Ross*). By Robert Bryant, B.A.

Having seen published as yet no discussion of all the observations of this comet, the reduction of the same was undertaken, and the results below are communicated, as they may be not without interest to the Society.

The reason for no complete determination of the elements having been made is perhaps due to the scant material upon which to work, and to the fact that few as the observations are, they do not in general show that agreement with an ephemeris computed from approximate elements which they should do.

From the mean of two sets of approximate parabolic elements an ephemeris was computed, extending from a few days before the first observation of the comet to a few days after it ceased to be visible, and as this ephemeris was originally intended to form the basis of the subsequent determination of the elements, it was computed with the greatest care for alternate days in order to reduce the possibility of error in the interpolation. This was interpolated with fourth and sometimes fifth differences, and the results when corrected for parallax were compared with all the published observations of the comet. Many of the observations then showed far greater and irregular discordances than could be attributed to errors of computation.

On the suggestion, therefore, of Dr. Hind (to whom my thanks are due for the assistance rendered in this and in work of a kindred nature) it was resolved to obtain the elements from Tebbutt's observations alone, which presented almost uniform discordance when compared with the ephemeris.

To this end a parabola was computed passing through the places of his extreme observations, and comparison was made with a middle place. It was found that although an agreement might be forced between the extreme observations and one coordinate of the middle place, yet the remaining coordinate exhibited a large error. It was, therefore, determined to obtain elements with an eccentricity different from unity, and to pass to these by means of differential equations.

The first corrections to the approximate elements were of such magnitude as to scarcely justify the assumption that the squares and higher powers of the differentials might be neglected. Consequently, fresh coefficients were calculated and a redetermination of the differentials made, the results of which are given below.

The elements from which the ephemeris was computed in the first instance are

T	... ...	1883, Dec. 25^d·30154 G.M.T.	
ω'	... ...	113° 36′ 50″·5	Mean Equator 1884·0
Ω'	... ...	254 33 46·1	
i'	... ...	110 37 51·1	
$\log q$	... ...	9·490993	

Comparison was made with the following three places observed by Tebbutt at Windsor, N.S.W.

	Windsor M.T.	R.A.	Decl.
	d h m s	h m s	° ′ ″
1884, Jan.	19 9 37 42	22 54 35·62	−41 46 56·3
	19 9 37 42	22 54 35·53	−41 46 56·5
	25 9 14 35	23 22 33·60	−41 59 19·6
	25 9 14 35	23 22 33·79	−41 59 18·7
Feb.	2 9 38 9	23 48 47·64	−41 44 19·1

the mean of each double observation being taken.

The respective corrections to two sets of elements gave the following approximate elliptic elements :—

T	...	1883, Dec. 25^d·139019 G.M.T.		1883, Dec. 25^d·137890 G.M.T.	
ω'	...	112° 43′ 47″·01	Mean Equator 1884·0	112° 43′ 34″·65	Mean Equator 1884·0
Ω'	...	254 29 51·25		254 30 35·61	
i'	...	110 21 18·98		110 21 22·05	
$\log q$	...	9·4885050		9·4886041	
e	...	0·9855308		0·9851042	

These give the following residuals for the three observations above (obs.-comp.).

I.	$d\alpha \cos\delta$	+8″·53	+10″·51	+13″·39
	$d\delta$	−1·64	− 1·65	− 0·67
II.	$d\alpha \cos\delta$	+13·72	+14·88	+19·06
	$d\delta$	− 0·35	− 0·99	− 1·72

From the first of the above sets of elements a new set of differential coefficients was derived and the following equations

were obtained, the first and second independent terms in each equation referring respectively to the residuals in the three places derived from the first and second set of elements :—

$8{\cdot}03449_n dT + 9{\cdot}70595 de + 9{\cdot}99668 d\log q + 9{\cdot}73417_n d\Lambda' + 9{\cdot}58974_n \sin i' d\Omega' + 7{\cdot}88138 di'$

					$= 1{\cdot}09528,\ 1{\cdot}30202$
$8{\cdot}22898$	$8{\cdot}61768_n$	$9{\cdot}92744$	$9{\cdot}58653_n$	$0{\cdot}00377_n$	$9{\cdot}68413$
					$= 0{\cdot}37953_n,\ 9{\cdot}70874_n$
$7{\cdot}74293$	$9{\cdot}77043$	$0{\cdot}04388$	$9{\cdot}82666_n$	$9{\cdot}59120_n$	$8{\cdot}81171_n$
					$= 1{\cdot}18531,\ 1{\cdot}33639$
$8{\cdot}11376$	$7{\cdot}75546_n$	$9{\cdot}91114$	$9{\cdot}60366_n$	$9{\cdot}97886_n$	$9{\cdot}75593$
					$= 0{\cdot}38120_n,\ 0{\cdot}15935_n$
$7{\cdot}28605_n$	$9{\cdot}82430$	$0{\cdot}05673$	$9{\cdot}88482_n$	$9{\cdot}59477_n$	$9{\cdot}17915_n$
					$= 1{\cdot}28810,\ 1{\cdot}44145$
$8{\cdot}00727$	$8{\cdot}49576$	$9{\cdot}89973$	$9{\cdot}63295_n$	$9{\cdot}94917_n$	$9{\cdot}80384$
					$= 9{\cdot}98727_n,\ 0{\cdot}39675_n$

where $d\Lambda' = d\omega' - d\Omega'$.

The differentials of T, q, and e are expressed in parts of the radius as unity.

In these equations the addition and subtraction was performed by logarithms and checked by natural numbers.

Finally, all the unknowns were substituted in the last of the equations, the agreements between the true and computed values of the independent terms showing that the solution had been correctly performed.

The following are the values of the differentials :—

dT	$-0{\cdot}013386,$	$-0{\cdot}004733$
$d\log q$	$-0{\cdot}0002293,$	$-0{\cdot}0002422$
de	$-0{\cdot}0012183,$	$+0{\cdot}0000121$
$d\Lambda'$	$-287''{\cdot}49,$	$-67''{\cdot}07$
$d\Omega'$	$-\ 5{\cdot}45,$	$-59{\cdot}79$
di'	$-\ 87{\cdot}14,$	$-49{\cdot}73$

and thus the following elements are obtained :—

T	...	1883, Dec. $25^d{\cdot}125633$ G.M.T.	1883, Dec. $25^d{\cdot}133157$ G.M.T.
ω'	...	$112^\circ\ 38'\ 54''{\cdot}07$	$112^\circ\ 41'\ 27''{\cdot}79$
Ω'	...	$254\ 29\ 45{\cdot}80$	$254\ 29\ 35{\cdot}82$
i'	...	$110\ 19\ 51{\cdot}84$	$110\ 20\ 32{\cdot}32$
$\log q$	...	$9{\cdot}4882757$	$9{\cdot}4883619$
e	...	$0{\cdot}9843125$	$0{\cdot}9851163$
P	...	86·915 sid. years	94·075 sid. years

These elements do not exhibit *inter se* that agreement which

one might expect, considering that they are both derived from the same observations. They are presented, however, simply as the results of computation, and may serve to illustrate the difficulty of determining the orbit from the data.

The following residuals show how closely each set of elements represents the observed places (obs.-comp.) :—

I.	$d\alpha \cos\delta$	+0″·86	+0″·11	+0″·07
	$d\delta$	+0·19	+0·08	−0·81
II.	$d\alpha \cos\delta$	+0·25	+0·07	+0·24
	$d\delta$	−0·12	0·00	−0·07

An inspection of the observed places shows at once that these residuals are far within the errors of observation.

These elements referred to the ecliptic are

T	1883, Dec. 25^d·625633 Univ. Time*	1883, Dec. 25^d·633157 Univ. Time†
ω	137° 37′ 40″·49	137° 40′ 21″·68
Ω	264 12 29·31	264 12 38·65
i	114 44 24·00	114 45 4·69
	Mean Ecliptic 1884·0	Mean Ecliptic 1884·0
log q	9·4882757	9·4883619
e	0·9843125	0·9851163
P	86·915 sid. years	94·075 sid. years

Throughout the whole computation checks and the method of differences have been employed wherever such were applicable; in default of these the calculation has always been performed in duplicate, and where possible by independent means. Although the agreement between observation and computation is satisfactory, and although the determination of the elements has been made with every possible care (from logarithms to seven places of decimals, and, where the variation was rapid, from eight places in order to get the seventh correct), yet it must be remembered that in addition to the difficulty of making the observations, the results are derived from only three places, that the extreme observations are separated by an interval of only 14 days, and that the included arc of anomaly is only 14°.

My thanks are also due to Professor Oppolzer, of Vienna, for his suggestions in connection with the work.

London: 1885, *June.*

* *i.e.* 1883, Dec. 25^d·125633 G.M.T. in the ancient mode of reckoning.
† *i.e.* 1883, Dec. 25^d·133157 „ „

Reply to Mr. Stone's Paper on Screw Errors as affecting the N.P.D. of the Cape Catalogue for 1880. By David Gill, LL.D., F.R.S., Her Majesty's Astronomer at the Cape of Good Hope.

In the following paper it will be convenient to take up the points raised by Mr. Stone nearly in the order in which he has stated them.

A considerable portion of my paper, which originated the present discussion, was devoted to a proof that errors of considerable magnitude were produced by wear of the screws and not by constraint, as argued by Mr. Stone.

Mr. Stone appears now to have given up that theory, as he does not support it by any further argument; and whilst admitting that wear may take place, he denies that such wear is sufficient to lead to serious errors in the resulting N.P.D.'s.

Here it will be well to define what are to be considered "serious errors" in this discussion.

A Star Catalogue may be judged by various standards.

1st. Merely as a Zone Catalogue, in which the differences of N.P.D. from standard stars are pretty accurately observed, the adopted places of the standard stars being the reference points of each zone. Or,

2nd. The N.P.D.'s may be considered fundamental, that is proper, without the application of any corrections, for discussions of the law and constant of refraction, the determination of precession and the solar motion in space, and for refined investigations on proper motion.

In the former case an error of $0''.5$, due to accidental screw error, cannot be considered "serious." But in the latter case, if even a much smaller error than $0''.5$ is systematically applicable to the observations of a long successive period, then we must regard such error as "serious," because the Cape (1880) Catalogue having been observed in zones of 10° in Declination, all the results of large adjacent portions of the Catalogue will, in such case, be affected systematically by that common error.

From Mr. Stone's expression (p. 140) of the "hope that Mr. Gill will be better advised than to apply empirical corrections to the Cape (1880) Catalogue," it must be understood that Mr. Stone regards the N.P.D.'s of his Catalogue as fundamental, and consequently that criticism belonging to the latter of the two classes above indicated is legitimately applicable to them.

Passing over, for the moment, all questions as to the origin of the screw errors, and appealing directly to facts, as Mr. Stone desires, the matter in discussion is fortunately reduced to a very simple one by the admission of Mr. Stone that "the curve which Mr. Gill has given (representing the errors of the screws) is the

reproduction of one which I (Mr. Stone) constructed from these observations in 1877."

I have never seen the curve to which Mr. Stone refers; but it is at least satisfactory to find that, from the same observations, we have arrived precisely at the same curve.

That curve gives the figures in Table V., p. 86, of my original paper, and we have therefore only to deal with precise figures about the accuracy of which there is no question.

Any given observation made about the epoch 1877 can thus be rigorously corrected for screw error from the data of Table V., provided that we know the original readings of the screws.

1st. In the observation of the star.
2nd. In determining the runs.
3rd. In the Nadir determination.

Unless, therefore, Mr. Stone can point to some error in the method of computation employed (described at p. 87) he must admit the accuracy of my Tables VII. and VIII.

As Mr. Stone instructed his assistants not to make observations below $5^{r}\cdot0$ (Mr. Stone's negative readings), it will be assumed in the following discussion that no such readings have been made, although, as a matter of fact, not a few of such exist. But apart from these readings we must suppose that the other readings fall with equal frequency on any part of the screw from $5^{r}\cdot0$ to $10^{r}\cdot0$, for it is impossible to restrict the supposed range within narrower limits.

Thus, if

r_o is the accidental mean error of observation,

r_s is the error due to the screw.

Then the mean error of the Catalogue place of any star is

$$r_o = \sqrt{\frac{r_o^2}{n} + r_s^2}$$

where n is the number of observations.

This expression would not be true if the star was observed over a considerable range of the Declination micrometer screw, because in that case different readings of the Circle microscopes would have been employed in each observation, and thus there might have been a tendency to eliminate to some extent the errors of these microscopes. But it was the practice of the observers to set the micrometer screw, for periods of many months together, always at or very near the same reading (within a very few seconds of arc), and to place the horizontal wire on the image of the star as it entered the field before clamping in N.P.D. The reason was doubtless to render the observations as nearly as possible independent of the adopted value of the Declination micrometer screw, but it has the effect of bringing the whole errors of the screws at the particular reading into the mean Catalogue place of the star.

If the reading for a particular star fell between $6^{r}\cdot0$ and $9^{r}\cdot3$ the error due to the Circle micrometer screws (apart from the systematic error of run and Nadir point) never exceeds $\pm0''\cdot1$, *but one-third of the observations must of necessity fall above or below these limits, when the accidental error so introduced ranges from* $0''\cdot1$ *to* $0''\cdot95$. It is surely important to correct such errors, when one has access to the original observations, if a refined investigation of the proper motion of a particular star is being made.

Much as such errors are to be regretted in the original results, they do not affect the Catalogue systematically.

That is to say, if, for example, we compare a number of stars as observed in Europe and at the Cape, for discussion of the law and constants of refraction, such accidental errors, due to the Circle screws, might be supposed to be practically eliminated in the mean of a large number of stars.

But the practice of observing the Nadir for long periods at the same reading of the Declination micrometer, coupled with the errors of the screws, has led to systematic errors extending over large contiguous portions of the Catalogue.

From January 1871, when the work of the Catalogue was commenced, till 1872, May 13, the whole of the Nadir readings (except a few negative readings) are made between $5^{r}\cdot0$ and $5^{r}\cdot5$, for the lower reading of the Circle microscopes, the mean reading, as well as the great majority of the readings being at $5^{r}\cdot3$. During that period the practice followed by all the observers was to set the telescope-micrometer to $10^{r}\cdot0$, and then to clamp in N.P.D., when the direct and reflex images of the horizontal wire were nearly in coincidence. On 1872, May 13, a change suddenly occurs in the Nadir reading, produced by a change in the drum, by which the number of whole revolutions is read off. That is to say, on 1872, May 13, the same nominal reading of the counter drum corresponds with a portion of the screw differing by two revolutions from that which it formerly did. This change seems to have been produced by accident.

The counter drum is driven by an endless screw acting on a toothed edge cut in the drum, the axis of the endless screw terminating in a pinion which is acted on by a bevel wheel attached to the head of the Declination micrometer screw. By long use the screw and fine teeth became worn, so that a slight accidental pressure on the counter-head was sufficient to cause it to slip. The "arbitrary changes" recorded in the published Tables of Nadir appear to be entirely due to the accidental slipping of the counter drum, and the observers have persevered in the same nominal settings of the Declination micrometer. On 1874, November 10, the fine teeth had become so worn at the point corresponding with 10^{r} that the counting drum was shifted forty divisions forward, so that the screw might work in teeth that were less worn. From this date till the end of 1879 the observers systematically observed the Nadir at 50^{r}, but there

are frequent cases of slipping of the counter (or arbitrary changes of a number of whole revolutions). These are all recorded in the following Table IX. Thus the "arbitrary changes" define a series of epochs, through each of which the Nadir readings were made systematically at nearly the same readings, and all systematically differing from the Nadir readings of the adjoining epochs.

To complete our knowledge of the systematic errors of the N.P.D.'s in each of these epochs (as distinguished from the accidental errors already described) we have only to ascertain the part of the screw at which the determinations of run were made. In observing the run an undeviating routine has been followed, and the great mass of the observations have been made with the lower reading about $5^r{\cdot}2$ to $5^r{\cdot}4$. The general distribution may be judged of from the Table for 1872–3, at p. 81, though after that the range is still more restricted.

In Table IX. the mean lower reading of the run is given for each of the epochs.

Table IX.

1 Rotation Number.	2 Limiting Dates of Epoch.	3 Mean Nadir Reading.	4 Lower Reading for Runs	5 Range of Errors.	6 Mean Error.	7 Systematic Error.
		r	r	″ ″	″	′
I.	1871, Jan. 1 – 1872, May 12	5·3	5·3	−0·59 to +0·41	±0·31	+0·24
II.	1872, May 13 – 1873, May 28	6·2	5·3	−0·90 to +0·10	±0·20	−0·07
III.	1873, May 29 – 1875, Jan. 31	6·7	5·3	−0·95 to +0·05	±0·22	−0·12
IV.	1875, Feb. 1 – 1875, Feb. 15	9·1	5·3	−0·81 to +0·19	±0·19	+0·02
V.	1875, Feb. 16 – 1875, Mar. 10	6·4	5·3	−0·92 to +0·08	±0·20	−0·09
VI.	1875, Mar. 11 – 1875, Apr. 4	6·9	5·3	−0·96 to +0·04	±0·22	−0·13
VII.	1875, Apr. 5 – 1875, May 10	7·4	5·3	−0·98 to +0·02	±0·24	−0·15
VIII.	1875, May 11 – 1875, May 12	9·5	5·3	−0·75 to +0·25	±0·21	+0·08
IX.	1875, May 13 – 1875, July 20	7·0	5·3	−0·97 to +0·03	±0·23	−0·14
X.	1875, July 21 – 1876, Feb. 20	7·6	5·3	−0·99 to +0·01	±0·24	−0·16
XI.	1876, Feb. 3 – 1876, Mar. 22	8·6	5·3	−0·90 to +0·10	±0·20	−0·07

1 Rotation Number.	2 Limiting Dates of Epoch.	3 Mean Nadir Reading.	4 Lower Reading for Runs.	5 Range of Errors.	6 Mean Error.	7 Systematic Error.
		r	r	" "	"	"
XII.	1876, Mar. 23 to 1876, Oct. 13	6·7	5·3	−0·95 to +0·05	±0·22	−0·12
XIII.*	1876, Oct. 16 to 1878, Dec. 31	7·2	5·3	−0·99 to +0·01	±0·24	−0·16

In the preceding Table

Column 1 is a rotation number adopted for convenience of reference.

„ 2 gives the range of date in the epoch during which the Nadir readings were made at practically the same parts of the microscope screws, for reasons above stated.

„ 3 gives the mean Nadir readings during the corresponding epoch.

„ 4 gives the mean lower reading for runs.

„ 5 gives the range of error when computed for each $\frac{1}{10}$ of a revolution from $5^{r}\cdot0$ to $10^{r}\cdot0$ from Table V., p. 86, by the method and formulæ on page 87, with the arguments N from Column 3, and R from Column 4 of Table IX.

„ 6 gives the *mean error* (or the square root of the mean of the squares of the errors) computed for each $\frac{1}{10}$ of a revolution from $5^{r}\cdot0$ to $10^{r}\cdot0$.

„ 7 gives the systematic error of the zone, computed on the assumption that the readings fall as often at $5^{r}\cdot0$ as at $5^{r}\cdot1$, as at $5^{r}\cdot2$, &c. . . . $10^{r}\cdot0$— in other words, the algebraic mean of the errors computed for each $\frac{1}{10}$ of a revolution.

The most important facts to be deduced from this Table are :

First. That whilst the wear of the screws produces accidental errors which range from $-0''\cdot99$ to $+0''\cdot41$ (see Column 5), the *mean error* of any N.P.D. taken by chance (as in the comparison of two Catalogues) ranges from $\pm0''\cdot19$ to $\pm0''\cdot31$ (see Column 6).

Second. That excepting the two brief epochs IV. and VIII. there is a *systematic difference* of nearly $0''\cdot4$ between the N.P.D. for Epoch I. and the rest of the Catalogue.

Mr. Stone appeals to a comparison between the N.P.D.'s of

* Except on 1876, Oct. 20, when the counter was displaced one revolution, and readjusted before the work of next night. The counter seems to have had a frequent tendency to slip, but during Epoch XIII. it seems to have been always carefully replaced to the same reading for the same revolution of the screw.

the Cape 1860 and 1880 Catalogues as a proof of the freedom of the latter from errors due to wear of the screws. His selection of the stars rests on a very clear and intelligible basis, and his appeal to such evidence seems at first sight a perfectly fair one.

But it is necessary in discussing so nice a question to take the most minute precautions in arriving at the preliminary data, and here it does not appear that Mr. Stone has stated in sufficient detail the facts which have led to the assumption on which his argument is based.

Mr. Stone quotes "the three independent sources of error" which enter into the discordances, besides the hypothetical errors which may be due to errors of the screws.

These are in his own words the following :—

(1) There will be the error of the N.P.D. given in the Cape Catalogue 1860; I shall certainly not over-estimate the probable error due to this cause by taking

$$e_{1860} = 0''{\cdot}1.$$

(2) There will be the combined effects of error in the precession constant, and adopted proper motion for 20 years. As this cannot be less than 0″·1, and will be about one-sixth of that due to the relative errors of Bradley's N.P.D. and the recent Greenwich observations, I cannot over-estimate the probable error by taking

$$e_m = 0''{\cdot}2.$$

(3) There will be the probable error of the N.P.D. of the Cape Catalogue of 1880. As there are generally only three or four observations employed in fixing the N.P.D., the probable error, independently of any possible error due to screw wear, will be about

$$e_{1880} = 0''{\cdot}25.$$

Now, as our object is to determine the existence or amount of a small hypothetical error from discordances which include three other independent sources of error, it is obvious that very small errors in our estimates of each of the three independent sources of error may entirely vitiate the result. I propose therefore to re-examine Mr. Stone's assumptions, as he has not stated the grounds on which they have been arrived at.

It must be remembered that the two Catalogues in question rest on observations made with the same instrument, in the same situation, with the same division errors, the same thermometers similarly exposed, and reduced with the same refraction tables. Therefore coincidence in the results is no more proof of absolute accuracy than any similar continuous series of observations with the same instrument in the same year. We may therefore obtain data to arrive at a sufficiently exact estimate of errors (1) and (3) from the accordance *inter se* of the results of N.P.D. for one or more stars observed in a single year. I have therefore selected twelve stars which have been the most frequently observed both in 1856 and 1860, and have deduced the *mean error* of a single observation in N.P.D., and find it to be

$$r_{1860} = \pm 0''{\cdot}7144.$$

For the 1880 Catalogue I have selected a number of frequently observed stars from the published ledgers, and deduced the mean error of a single observation

$$r_{1880} = \pm 0''.6214,$$

and these mean errors do not differ very materially from the probable errors of Mr. Stone's sources of discordance (1) and (3).*

But I am quite at a loss to understand the meaning of Mr. Stone's statement (above quoted) relative to his source of error (2). Does Mr. Stone imply that the probable error of the annual variation of stars, such as he has selected (which have been observed by Bradley, Piazzi, and at every observatory in the world since), amounts to $\pm 0''.01$ (*i.e.* $\frac{1}{20}$ of $0''.2$), and that of all these observations the only reliable data for determining the annual variation are the observations of Bradley and the modern Greenwich observations? I do not think that either one or other of these opinions will receive the support of astronomers.

It fortunately becomes unnecessary to discuss these points here by simply referring Mr. Stone to Professor Lewis Boss's work on the Declination of the fixed stars; where, in the final Catalogue, there is a column which gives for each star the "probable error of annual variation," not as *adopted* by Professor Boss, but as rigorously deduced by him from the data at disposal.

Of Mr. Stone's 93 stars, 53 occur in Professor Boss's Catalogue, and the mean of the probable errors for the annual variations of these 53 stars is $\pm 0''.0031$, so that Mr. Stone's estimate appears to be fully three times too great.

The *mean error* corresponding to a probable error of $\pm 0''.0031$ is $\pm 0''.00458$, which for twenty years corresponds with

$$r_m = \pm 0''.091,$$

where r_m is the *mean error* of the annual variation in twenty years.

To find, from the discordances between the 1860 and 1880 Catalogues, the mean error of a star's place due to errors of the screw, we have then the following equation from each of Mr. Stone's stars:—

$$(1860 \text{ Cat.} - 1880 \text{ Cat.})^2 = \frac{r^2_{1860}}{n_{1860}} + \frac{r^2_{1880}}{n_{1880}} + r^2_m + y^2,$$

where r_{1860}, r_{1880}, r_m have the values already found, and where the mean value of y will be found from the mean of the equations.

* The probable errors (1) and (3) become for the mean number of observations (33 and 34 respectively), $\pm 0''.083$ and $\pm 0''.21$, instead of $\pm 0''.1$ and $\pm 0''.25$, as adopted by Mr. Stone.

This value of y should agree precisely with that of Column 6 of Table IX. (viz. about $\pm 0''\cdot 23$) provided—

(α) That the Circle screws were absolutely perfect during the period 1855–60.

(β) That each star of Mr. Stone's list was observed throughout the whole of the observations upon which its place in the 1880 Catalogue depends, with the same readings of the micrometer screw. (If this is not assumed, then in each equation we must write $\frac{y^2}{n_{1880}}$ for y^2).

Now, as a matter of fact, neither of these two conditions is fulfilled. It has already been shown, in my original paper, that during a similar period the screws, which were new and practically errorless in 1880, had acquired decidedly serious errors by wear in 1884. It is, therefore, reasonable to argue that similar screws of similar material and made by the same makers would also acquire similar errors from constant use between 1855 and 1860. The partial wear of the screws in the period 1855–56 would therefore tend to diminish the discordance between the 1860 and 1880 Catalogue, and hence also the value of y.

The second condition is not fulfilled because the stars selected for this comparison by Mr. Stone (for other and sufficient reasons) are not zone stars, but clock stars, the Declinations of which have been observed for the 1880 Catalogue at miscellaneous epochs (epoch being here understood in the sense of Table IX.), and consequently in many cases the same star has been observed with different Nadir points and different readings of the micrometer screw. In this way the effect of errors of the screws is to some extent eliminated, and hence the resulting value of y will be diminished.

Thus, because the conditions (α) and (β) are not *fulfilled*, the *mean* value of y, computed from the discordances of the two Catalogues, should not amount to the full theoretical amount of Table IX. Column 6—that is, it should be less than $\pm 0''\cdot 23$.

We find accordingly from the sum of the equations—

$$93\,y^2 = 3\cdot 0051,$$

and thence

$$y = \pm 0''\cdot 18.$$

Thus the very stars which Mr. Stone has chosen, when fairly and properly discussed, prove the existence of errors which correspond in effect with those deduced in my original paper from quite different data.

Mr. Stone contends that if x (the portion of the *probable error* in a star's place which is due to errors of the screws) did not amount to $\pm 0''\cdot 5$ (in other words, if y in the present dis-

cussion did not amount to $\pm 0''.74$), then my paper should not have been written.

I am sorry that Mr Stone thinks so.

When it is remembered that, from the form of the curve of error which such a screw acquires from the process of wear, nearly two-thirds of the part of the screw in use must have very small errors, the errors of the remaining one-third of the screw must be very large to produce a computed *mean* error for the whole screw of $\pm 0''.74$. Some of the absolute errors would in that case amount to nearly $3''$.

Does Mr. Stone contend that all errors under such an amount should be passed without notice or mention? I do not think so; and I feel sure that when Mr. Stone further considers the matter he will not think so.

I hold rather that in fundamental observations we have such numerous sources of error which almost elude our search, that we cannot afford to dispense with the rigid correction of any error that is capable of being so easily and certainly determined as the errors of the screws. It is because I have felt this, and because, in special cases, it will be useful to apply corrections for these screw errors to the 1880 Catalogue, and because it was important that further proof should be given to astronomers of the necessity for rigid determination of the errors of the microscope screws from time to time, that my original paper was written. These are surely sufficient reasons even if the resulting errors had been much smaller than they have proved to be.

But Mr. Stone contends that the corrections which were applicable in 1877 would not be applicable at another time, not because the wear of the screws might be sensibly different in 1871 and 1877, but "from changes in the adjustment of the index from which the revolutions are taken."

It is, however, easy to show that no such changes occurred in the Cape Circle till 1879. The "drums," by which the fractions of a revolution are read, are not attached by mere friction to the screws as in some transit circles, but are squared on, there being a square hole in the drum-head fitting a slightly tapering square on the end of the axis of the screw; and the fit is so nice that the drum will only go home when one marked face of the tapered square is placed against one marked surface of the square in the drum. Thus no change of a fraction of a revolution in the readings can be made.

The bearings of the screws also are immovable, being hollow cones bored in projections cast in one flow with the gun-metal ring to which all the microscopes are attached.

The only way, therefore, in which a real change of a whole revolution in any particular microscope could be made would be by changing the comb one revolution; and to restore the similarity of the numerical readings of the six microscopes, the object-glass of the microscope in question would have to be shifted in a plane at right angles to the microscope axis in a direction parallel to

the screw. The microscopes have no tubes in the ordinary sense, the mounting of each objective being attached to a piece of brass, which is bolted to the face of the pier, the tubes being simply holes in the pier.

The only means of giving side adjustment to the object-glass is by widening the holes in the flanges, through which the screws pass, by which the objective mountings are screwed to the piece of brass in question.

I do not think that the holes in the flanges of any of the object-glasses are sufficiently widened to allow so large a shift as $\pm 1^r$; and besides, we have it on the authority of Mr. Stone (Introduction to Cape Observations, 1875, p. xi.) that "the effective range of the screws in the Cape microscopes does not extend, at most, over more than six revolutions;" therefore, such a change as one revolution could not be made.

The changes that may have been made from time to time in the relative position of the object-glasses have thus been limited to quantities corresponding with a fraction of a revolution, and as the object of any such changes should have been (and in Mr. Stone's experienced hands would certainly have been) merely to render the readings of the microscopes as nearly the same as possible, there would have been no object in attempting to make larger changes. Such small changes can readily be allowed for by taking for argument in the table of screw corrections not the reading of microscope A only, but the mean of the readings of the six microscopes, and this has been done throughout the present discussion.

Mr. Stone (Introduction to Cape Observations, 1875, p. xi.) quotes observations of the Nadir on 1875, November 22, by three observers, of which the means are the following:—

	Reading of A.	
	0^r	$2^r{\cdot}0$
Nadir	180° 7′ 26″·62	26″·29,

and he adds, "it appears from observations made in the present year (1877), and carried systematically over the whole range of the screws, that the difference above indicated is real, but is about as large as the greatest difference obtained throughout the range of the screws employed in the observations."

Why does Mr. Stone not quote those observations of 1877 which prove the reality of the above difference, and which also appear to me to prove differences from two to three times as great (see Table V.), even when negative readings are excluded? Indeed, the above observations seemed to me at first to prove that from the comparatively small discordance (0″·33) between the Nadirs of 0^r and $2^r{\cdot}0$ the screw errors really were different and smaller in 1875 than in 1877. According to our Table V., if the readings were made at 0^r and $2^r{\cdot}0$ (*i.e.* at $5^r{\cdot}0 + 7^r{\cdot}0$) the screw errors should have produced a difference of about 1″ in the two Nadirs.

But on turning to the original observations I find that the readings of micrometer A were not 0^r and $2^r{\cdot}0$, but $0^r{\cdot}7$ and $2^r{\cdot}7$, the mean of the six microscopes being $0^r{\cdot}56$ and $2^r{\cdot}56$. The lower reading of microscope A for the run was also $0^r{\cdot}7$, or for the mean of the six microscopes, $0^r{\cdot}56$.

With these means as arguments we can correct the Nadir by our Tables V. and VI.; the corrections are respectively $-0''{\cdot}20$ and $+0''{\cdot}21$, so that the corrected Nadirs become

Microscope Reading.

	$0^r{\cdot}56$	$2^r{\cdot}56$
Nadir 180° 7′	$26''{\cdot}42$	$26''{\cdot}50$,

an agreement which is sufficiently precise.

But it may be fairly argued that during the period 1871–77 a very large number of observations was made, and therefore the screw errors would change considerably by wear between these dates. There is no doubt that this must be so, but probably not to the extent that may at first be supposed.

From a discussion of the runs observed at different times, and over different parts of the screw, during the period 1880–1884 (the details of which will be published in the Cape Observations), I find that the wear does not change proportionally with the number of observations, but is expressed for an epoch between 1880 and 1885 by ak, where k is the error of the screw produced by wear after N observations (N being actually about 17,000 when the screw errors were determined in 1884), and

$$a = 1{\cdot}57\,\frac{n}{N} - 0{\cdot}57\left(\frac{n}{N}\right)^2.$$

where n is the number of observations made since 1880 at the epoch for which the error is required.

That is to say, the wear is much more rapid at first than afterwards; for if the expression were true the wear would cease in eight years, and afterwards diminish! The formula is of course merely used as a sufficiently approximate form of interpolation.

We may also arrive at a like conclusion by other facts.

The second set of screws, mounted in 1880, are of the same material and made by the same artists as the first set. We may probably conclude, therefore, that the law of wear of both sets would be nearly alike.

The curve of errors of the new screws (as determined by careful measurement with the apparatus described and figured at pp. 64–65) is given in the following diagram (fig. 8); these errors result from four years' wear, and are indicated by a continuous curve.

The curve of the errors of the old screws, resulting from twenty-one years' wear, is indicated by a dotted curve in the same diagram.

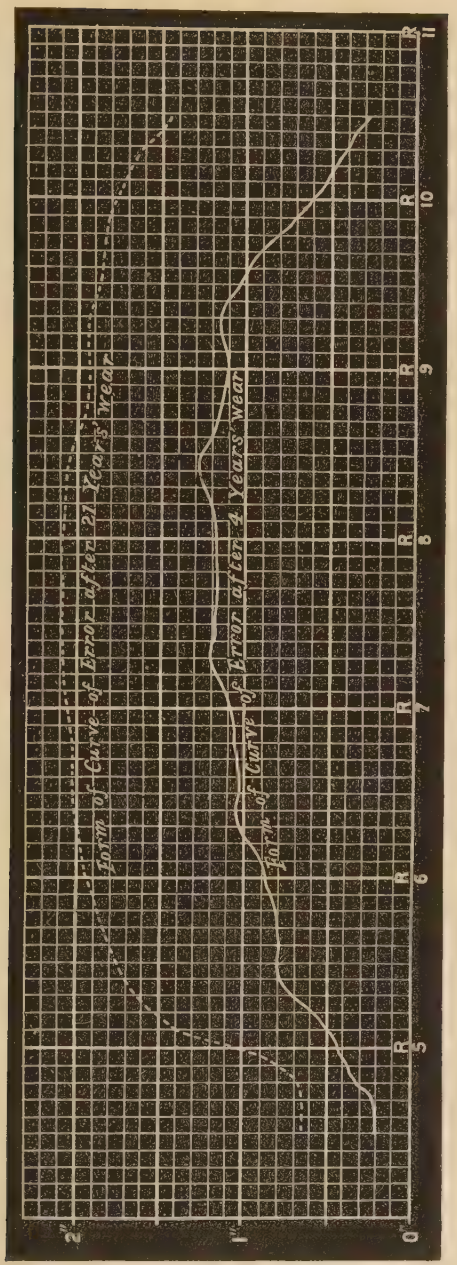

Fig. 8.—Curves showing errors of screws after twenty-one, and four years' wear.

It becomes obvious that the wear has been much less rapid during the last seventeen years than in the first four years of the screw's work, else the two curves would differ much more widely. This is probably because the deeply-cut male and female threads do not at first bear along the whole of the faces, but gradually, by mutual wear, attain to more complete contact of their bearing surfaces.

The discussion of a comparison between Right Ascensions of the Cape Catalogues for 1850 and 1880 appears to be somewhat irrelevant to a paper on screw wear; I therefore defer reply to Mr. Stone's remarks on this subject till a more fitting opportunity.

The Velocity of Meteors. By W. F. Denning.

At the December meeting of the Royal Astronomical Society, and again at the May meeting, certain remarks were made as to the velocity of meteors and the enormous speed necessary to explain the occurrence of fixed, long-enduring radiant points. I wish to say that no such velocities are observed, and that it is impossible the fixed radiants can be explained by this means. I quite agree with the remarks that emanated from Col. Tupman as to the difficulty of accounting for these long-continued showers, and also that the very great velocities indicated by Mr. Proctor have never been recognised. The meteors falling from the stationary radiants, referred to in my paper read at the December meeting, appear to be of ordinary character, and their motions cannot differ essentially from the parabolic velocities exhibited by the planetary streams.

Mr. Ranyard, at the May meeting, asked for information as to whether the speed from any of the assumed fixed radiants had been determined from multiple observations of bolides and large meteors. The velocity has certainly been computed in several instances, and they accord with that of the usual planetary meteors. Of course, there is rather a wide limit of error in estimating the exact durations of flight, the intervals being so transient in most cases; but it is impossible that the meteors can travel at a rate anything approaching that suggested as the only explanation of the long enduring showers.

Let us take the instance of the display from near ε *Persei* at $61°{\cdot}8+36°{\cdot}8$, No. IV. of my list in the *Monthly Notices* for Dec. 1884, p. 101, which I regard as one of the very best cases of stationary radiation. A shooting star of about the 3rd mag. was doubly observed from this shower, at York and Oxford, at $11^h\ 28\frac{1}{2}^m$ on Aug. 10, 1872. The estimated duration was 0·5 second, and the actual length of the path traversed in the atmosphere was 20·4 miles, so that the resulting velocity was about forty-one miles per second. The radiant point was at

61°+39° (B.A. Report on Luminous Meteors for 1874, p. 281). A great fireball from the same stream was observed at Bristol and many other parts of England on Nov. 6, 1869, at $6^h\ 50^m$. Prof. Herschel discussed a considerable number of observations, and found the radiant point at 62°+37°. The meteor had a real path of about 175 miles traversed in about five seconds, the velocity being some 35 miles per second, and somewhat greater than that of a body moving in a parabola. I observed the end of this fireball, and believe the duration to be much overestimated; still, though the motion may have been hyperbolic, it could not have attained a figure anything like the terrific velocities which Mr. Proctor's hypothetical streams must follow.

That this fireball really belonged to the shower near *ε Persei* is rendered conclusive by the fact that on Nov. 3 and 4, 1877, I observed an active display of ordinary swift meteors from the point 61°+35°. I also saw a radiant at nearly the same place on Sept. 7–16 and Nov. 27–Dec. 6, 1877, and the following are the mean relative velocities and length of path as I registered them at the three epochs:—

	Mean Duration.	Mean Length.	No. of Meteors.
	sec.	°	
1877, Sept. 7–16	·23	9·15	10
Nov. 3–4	·30	13·30	10
Nov. 27–Dec. 6	·46	7·30	5

The motions evidently decrease with increase of time as the radiant recedes from the Earth's apex, and this seems a general feature.

Whatever may be the true explanation of the fixed radiants, it is not that which applies to the meteors a velocity many times greater than that of the planetary streams.

Bristol:
1885, *June* 1.

Ephemerides of the Satellites of Saturn, 1885–86.

By A. Marth.

The five inner satellites deviate so little from the plane of the ring that their deviations are most suitably treated as latitudes above this plane, the ascending node N and inclination I of which in reference to the plane of the Earth's equator are here assumed to be

for 1886·0 $\quad N = 126°·5510 \quad I = 7°·0016.$

The assumed longitudes of the five satellites in their orbits (*i.e.* their longitudes from the ascending node added to the right ascension N of the ascending node reckoned from the point of

the true equinox), referred to the time when the light arrives at the distance [0·950], are the following:

0h Gr.	Mimas.	Enceladus.	Tethys.	Dione.	Rhea.
1885, Sept. 15	63°·253	314°·793	305°·911	93°·924	276°·687
Oct. 15	3·010	276·749	266·855	79·975	147·391
Nov. 14	302·768	238·705	227·799	66·027	18·095
Dec. 14	242·528	200·662	188·744	52·079	248·800
1886, Jan. 13	182·289	162·619	149·688	38·131	119·505
Feb. 12	122·050	124·576	110·633	24·183	350·209
Mar. 14	61·812	86·532	71·577	10·234	220·913
Apr. 13	1·576	48·488	32·521	356·285	91·617

The adopted daily sidereal motions of the five satellites and the corresponding periods of their sidereal revolutions are:—

		d h m s
Mimas	381°·99187	0 22 37 5·82
Enceladus ...	262·73186	1 8 53 6·86
Tethys	190·69812	1 21 18 25·96
Dione	131·53503	2 17 41 9·33
Rhea	79·69012	4 12 25 11·87

The values for *Mimas* belong to Sept. 15, 1885, and depend on the hypothesis of accelerated motion.

In the following tables P denotes the position-angle of the minor axis of the ring, $L+180°$ the planetocentric longitude of the Earth referred to the plane of the ring, $\Lambda+180°$ that of the Sun, or $\Lambda-L$ the difference between the two. The apparent equatorial diameter of the ball and the diameter of the outer rim of the ring depend still on Bessel's determinations. The assumed proportion of the polar axis of the ball to the equatorial diameter is 0·900.

In the tables for the satellites a and b are the semi-axes of the apparent orbits, $l-L$ the longitudes of the satellites in their orbits reckoned from the points which are in superior conjunction with the planet's centre or in opposition to the Earth in longitude. By adding to $l-L$ the value of L from the first table, the longitudes l are found.

The values of P, a, b, and $l-L$ are to be interpolated for the times for which the apparent positions of the satellites are required, and the rectangular coordinates x and y, reckoned parallel to the axes of the ring and expressed in seconds of arc, or, if polar coordinates are wanted, the position-angles p and distances s of the satellites in reference to the centre of the planet are then found by means of the equations

$$s \sin (p-P) = x = a \sin (l-L)$$
$$s \cos (p-P) = y = b \cos (l-L).$$

0^h Gr.	P	L	Latitude of Earth above plane of ring.	Latitude of Sun above plane of ring.	A−L
1885.					
Sept. 15	353°·188	100°·655	−25°·571	−26°·455	−6°·817
20	·171	100·969	·521	·440	6·922
25	·156	101·238	·477	·425	6·983
30	·144	101·461	·440	·410	6·998
Oct. 5	353·135	101·636	−25·410	−26·394	−6·966
10	·128	101·762	·388	·378	6·884
15	·124	101·838	·375	·361	6·752
20	·123	101·864	·370	·344	6·570
25	·124	101·839	·374	·327	6·338
30	·128	101·764	·387	·310	6·055
Nov. 4	353·135	101·639	−25·409	−26·292	−5·722
9	·145	101·465	·439	·274	5·340
14	·157	101·244	·476	·256	4·912
19	·171	100·980	·521	·238	4·440
24	·188	100·675	·573	·219	3·928
29	·207	100·333	·631	·200	3·378
Dec. 4	353·228	99·958	−25·693	−26·181	−2·796
9	·251	99·555	·759	·161	2·186
14	·276	99·131	·828	·141	1·555
19	·302	98·691	·899	·121	0·908
24	·329	98·242	−25·972	·100	−0·252
29	·356	97·789	−26·043	·079	+0·408
1886.					
Jan. 3	353·384	97·340	−26·113	−26·058	+1·064
8	·412	96·901	·182	·036	1·710
13	·439	96·478	·248	−26·014	2·340
18	·465	96·078	·310	−25·992	2·946
23	·489	95·707	·368	·970	3·523
28	·511	95·370	·421	·947	4·067
Feb. 2	353·531	95·070	−26·470	−25·924	+4·573
7	·549	94·812	·514	·901	5·037
12	·563	94·600	·552	·878	5·455
17	·574	94·437	·585	·854	5·825
22	·581	94·323	·612	·830	6·145
27	·585	94·260	·633	·806	6·414
Mar. 4	353·585	94·248	−26·649	−25·781	+6·631
9	·581	94·289	·659	·756	6·795
14	·574	94·382	·663	·731	6·907
19	·564	94·526	·661	·705	6·968

0^h Gr.	P	L	Latitude of Earth above plane of ring.	Latitude of Sun above plane of ring.	A−L
1886.	°	°	°	°	°
Mar. 24	353·550	94·720	−26·653	−25·679	+6·980
29	·533	94·962	·639	·653	6·943
Apr. 3	353·512	95·251	−26·618	−25·627	+6·860
8	·489	95·585	·592	·600	6·732
13	·463	95·960	·559	·573	6·561
18	·435	96·375	·519	·546	6·350
23	·405	96·827	·473	·518	6·103
28	·373	97·314	·421	·490	5·821
May 3	353·338	97·834	−26·363	−25·462	+5·505

0^h Gr.	Diameter of Ball. Equat.	Phase prec. l.	Polar	Axis of Ring. Major	Minor	*Mimas.* a_1	b_1	l_1-L	Diff.
1885.	″	″	″	″	″	″	″	°	°
Sept. 15	17·64	0·062	16·22	40·66	17·55	27·74	−11·97	321·91	1909·82
20	17·80	·065	16·36	41·02	17·67	27·98	12·06	71·73	·87
25	17·96	·067	16·51	41·39	17·81	28·24	12·15	181·60	·92
30	18·12	·067	16·66	41·77	17·94	28·50	12·24	291·52	1909·97
Oct. 5	18·29	·067	16·81	42·16	18·09	28·76	−12·34	41·49	1910·01
10	18·46	·066	16·97	42·55	18·25	29·03	12·45	151·50	·06
15	18·63	·065	17·13	42·95	18·41	29·30	12·56	261·56	·11
20	18·80	·062	17·28	43·34	18·57	29·57	12·67	11·67	·16
25	18·97	·058	17·44	43·73	18·74	29·83	12·78	121·83	·20
30	19·14	·053	17·59	44·11	18·91	30·09	12·90	232·03	·23
Nov. 4	19·30	·048	17·74	44·48	19·09	30·34	−13·02	342·26	1910·28
9	19·45	·042	17·88	44·83	19·26	30·58	13·14	92·54	·32
14	19·59	·036	18·01	45·17	19·43	30·81	13·25	202·86	·35
19	19·73	·029	18·14	45·47	19·59	31·02	13·36	313·21	·37
24	19·85	·023	18·25	45·75	19·75	31·21	13·47	63·58	·40
29	19·95	·017	18·35	46·00	19·90	31·38	13·57	173·98	·42
Dec. 4	20·05	·012	18·43	46·21	20·03	31·52	−13·67	284·40	1910·43
9	20·12	·008	18·50	46·38	20·16	31·64	13·75	34·83	·43
14	20·18	·004	18·56	46·51	20·26	31·73	13·82	145·26	·43
19	20·21	·001	18·59	46·60	20·35	31·78	13·88	255·69	·43
24	20·23	foll.	18·62	46·64	20·42	31·81	13·93	6·12	·41
29	20·23	limb.	18·61	46·63	20·47	31·81	13·96	116·53	·39
1886.									
Jan. 3	20·21	0·002	18·59	46·58	20·50	31·77	−13·98	226·92	1910·36
8	20·16	·004	18·56	46·48	20·51	31·71	13·99	337·28	·33
13	20·10	·008	18·50	46·34	20·49	31·61	13·98	87·61	·29

		Diameter of Ball. Equat.	Phase prec. l.	Polar	Axis of Ring. Major	Minor	*Mimas.* a_1	b_1	l_1-L.	Diff.
1886.		″	″	″	″	″	″	″	°	°
Jan.	18	20·02	0·013	18·43	46·16	20·46	31·48	−13·96	197·90	1910·24
	23	19·93	·019	18·34	45·94	20·40	31·33	13·92	308·14	·20
	28	19·82	·025	18·24	45·68	20·33	31·16	13·86	58·34	·15
Feb.	2	19·69	·031	18·13	45·39	20·23	30·96	−13·80	168·49	·09
	7	19·55	·038	18·00	45·07	20·12	30·75	13·73	278·58	1910·03
	12	19·41	·044	17·87	44·73	20·00	30·51	13·64	28·61	1909·97
	17	19·25	·050	17·73	44·38	19·86	30·27	13·55	138·58	·92
	22	19·09	·055	17·53	44·00	19·71	30·02	13·45	248·50	·86
	27	18·92	·060	17·43	43·62	19·55	29·75	13·34	358·36	·80
Mar.	4	18·75	·063	17·27	43·22	19·39	29·48	−13·22	108·16	1909·74
	9	18·58	·065	17·11	42·83	19·22	29·21	13·11	217·90	·69
	14	18·41	·067	16·95	42·43	19·04	28·94	12·99	327·59	·64
	19	18·24	·067	16·80	42·04	18·86	28·68	12·87	77·23	·58
	24	18·07	·067	16·64	41·65	18·68	28·41	12·74	186·81	·53
	29	17·90	·066	16·49	41·27	18·50	28·15	12·62	296·34	·49
Apr.	3	17·74	·064	16·34	40·90	18·33	27·90	−12·50	45·83	1909·45
	8	17·59	·061	16·20	40·54	18·15	27·66	12·38	155·28	·41
	13	17·44	·057	16·06	40·20	17·97	27·42	12·26	264·69	·38
	18	17·30	·053	15·93	39·87	17·80	27·20	12·14	14·07	·35
	23	17·16	·049	15·80	39·56	17·64	26·99	12·03	123·42	·32
	28	17·03	·044	15·68	39·27	17·47	26·79	11·92	232·74	1909·29
May	3	16·92	0·039	15·57	38·99	17·32	26·60	−11·81	342·03	

		Enceladus. a_2	b_2	l_2-L	Diff.	*Tethys.* a_3	b_3	l_3-L	Diff.
1885.		″	″	°	°	″	″	°	°
Sept.	15	35·58	−15·36	213·66	1313·47	44·05	−19·01	204·91	953·27
	20	35·90	15·47	87·13	·52	44 44	19·15	78·18	·31
	25	36·22	15·58	320·65	·56	44·84	19·29	311·49	·36
	30	36·55	15·70	194·21	·61	45·25	19·44	184·85	·40
Oct.	5	36·89	−15·83	67·82	1313·66	45·67	−19·60	58·25	953·46
	10	37·24	15·97	301·48	·70	46·10	19·76	291·71	·50
	15	37·58	16·11	175·18	·76	46·53	19·94	165·21	·55
	20	37·93	16·25	48·94	·80	46·95	20·12	38·76	·60
	25	38·27	16·40	282·74	·84	47·37	20·30	272·36	·65
	30	38·60	16·55	156·58	·89	47·79	20·49	146·01	·70
Nov.	4	38·92	−16·70	30·47	1313·94	48·19	−20·68	19·71	953·73
	9	39·23	16·85	264·41	1313·97	48·57	20·86	253·44	·78
	14	39·52	17·00	138·38	1314·01	48·93	21·05	127·22	·82

		Enceladus.				*Tethys.*			
		a_2	b_2	l_2-L	Diff.	a_3	b_3	l_3-L	Diff.
		"	"	°	°	"	"	°	°
1885. Nov.	19	39·79	−17·15	12·39	1314·04	49·26	−21·22	1·04	953·85
	24	40·04	17·28	246·43	·07	49·56	21·39	234·89	·88
	29	40·25	17·41	120·50	·09	49·83	21·55	108·77	·91
Dec.	4	40·44	−17·53	354·59	1314·11	50·06	−21·70	342·68	953·92
	9	40·59	17·64	228·70	·11	50·24	21·84	216·60	·94
	14	40·70	17·73	102·81	·13	50·38	21·95	90·54	·95
	19	40·78	17·81	336·94	·12	50·48	22·05	324·49	·95
	24	40·81	17·87	211·06	·11	50·52	22·12	198·44	·94
	29	40·81	17·91	85·17	·09	50·51	22·18	72·38	·93
1886. Jan.	3	40·76	−17·94	319·26	1314·07	50·46	−22·21	306·31	953·91
	8	40·67	17·95	193·33	·05	50·35	22·22	180·22	·89
	13	40·55	17·93	67·38	1314·01	50·20	22·20	54·11	·85
	18	40·39	17·90	301·39	1313·97	50·00	22·16	287·96	·82
	23	40·20	17·85	175·36	·93	49·76	22·10	161·78	·78
	28	39·97	17·79	49·29	·88	49·48	22·02	35·56	·73
Feb.	2	39·72	−17·70	283·17	1313·83	49·17	−21·92	269·29	953·69
	7	39·44	17·61	157·00	·77	48·83	21·80	142·98	·63
	12	39·15	17·50	30·77	·72	48·46	21·66	16·61	·58
	17	38·83	17·38	264·49	·67	48·07	21·51	250·19	·53
	22	38·51	17·25	138·16	·61	47·67	21·35	123·72	·47
	27	38·17	17·11	11·77	·55	47·25	21·18	357·19	·42
Mar.	4	37·82	−16·97	245·32	1313·50	46·82	−21·00	230·61	953·36
	9	37·48	16·82	118·82	·44	46·39	20·82	103·97	·30
	14	37·13	16·66	352·26	·39	45·96	20·63	337·27	·26
	19	36·79	16·51	225·65	·34	45·54	20·43	210·53	·20
	24	36·45	16·35	98·99	·29	45·12	20·24	83·73	·16
	29	36·12	16·19	332·28	·25	44·71	20·04	316·89	·11
Apr.	3	35·79	−16·04	205·53	1313·20	44·31	−19·85	190·00	·07
	8	35·48	15·88	78·73	·16	43·92	19·66	63·07	953·03
	13	35·18	15·73	311·89	·13	43·55	19·47	296·10	952·99
	18	34·89	15·58	185·02	·10	43·19	19·29	169·09	·96
	23	34·62	15·43	58·12	·06	42·86	19·11	42·05	·93
	28	34·36	15·29	291·18	1313·04	42·54	18·93	274·98	952·89
May	3	34·12	−15·15	164·22		42·24	−18·76	147·87	

		Dione.				*Rhea.*			
		a_4	b_4	l_4-L	Diff.	a_5	b_5	l_5-L	Diff.
1885.		"	"	°	°	"	"	°	°
Sept.	15	56·42	−24·35	353·03	657·42	78·79	−34·01	175·89	398·17
	20	56·92	24·52	290·45	·47	79·48	34·24	214·06	·22
	25	57·43	24·70	227·92	·52	80·20	34·50	252·28	·27
	30	57·96	24·90	165·44	·56	80·94	34·77	290·55	·31
Oct.	5	58·50	−25.10	103·00	657·61	81·69	−35·05	328·86	398·36
	10	59·04	25·31	40·61	·66	82·45	35·35	7·22	·41
	15	59·59	25·54	338·27	·71	83·22	35·66	45·63	·47
	20	60·13	25·77	275·98	·76	83·98	35·98	84·10	·51
	25	60·67	26·00	213·74	·81	84·73	36·31	122·61	·56
	30	61·20	26·24	151·55	·85	85·47	36·64	161·17	·60
Nov.	4	61·70	−26·48	89·40	657·90	86·18	−36·98	199·77	398·66
	9	62·20	26·72	27·30	·94	86·87	37·31	238·43	·70
	14	62·66	26·95	325·24	657·98	87·51	37·64	277·13	·74
	19	63·09	27·18	263·22	658·02	88·11	37·96	315·87	·78
	24	63·48	27·40	201·24	·05	88·65	38 27	354·65	·81
	29	63·82	27·61	139·29	·08	89·13	38·55	33·46	·84
Dec.	4	64·11	−27·80	77·37	658·10	89·53	−38·82	72·30	398·87
	9	64·35	−27·97	15·47	·12	89·87	39·06	111·17	·89
	14	64·53	28·12	313·59	·13	90·12	39·26	150·06	·90
	19	64·65	28·24	251·72	·13	90·28	39·43	188·96	·90
	24	64·70	28·34	189·85	·12	90·36	39·57	227·86	·90
	29	64·70	28·40	127·97	·12	90·35	39·67	266·76	·90
1886.									
Jan.	3	64·62	−28·44	66·09	658·10	90·25	−39·72	305·66	398·88
	8	64·49	28·45	3·19	·08	90·06	39·74	344·54	·86
	13	64·29	28·43	302·27	·05	89·78	39·71	23·40	·84
	18	64·04	28·38	240·32	658·02	89·43	39·64	62·24	·80
	23	63·73	28·30	178·34	657·98	89·00	39·53	101·04	·77
	28	63·38	28·20	116·32	·93	88·50	39·38	139·81	·73
Feb.	2	62·98	−28 07	54·25	657·89	87·94	−39·20	178·54	398 68
	7	62·54	27·92	352·14	·84	87·33	38·99	217·22	·63
	12	62·07	27·74	289·98	·79	86·67	38·75	255·85	·58
	17	61·57	27·55	227·77	·73	85·98	38·48	294·43	·54
	22	61·05	27·35	165·50	·68	85·25	38·19	332·97	·48
	27	60·51	27·13	103·18	·63	84·51	37·88	11·45	·42
Mar.	4	59·97	−26·90	40·81	657·58	83·75	−37·56	49·87	398·37
	9	59·42	26·66	338·39	·52	82·98	37·23	88·24	·32
	14	58·87	26·42	275·91	·46	82·21	36·89	126·56	·27

	Dione.				*Rhea.*			
	a_4	b_4	l_4-L	Diff.	a_5	b_5	l_5-L	Diff.
1886.	″	″	°	°	″	″	°	°
Mar. 19	58·32	26·17	213·37	657·42	81·45	36·55	164·83	398·22
24	57·79	25·92	150·79	·37	80·70	36·20	203·05	·17
29	57·26	25·67	88·16	·33	79·96	−35·85	241·22	398·13
Apr. 3	56·75	−25·42	25·49	657·29	79·25	35·51	279·35	·08
8	56·25	25·18	322·77	·24	78·55	35·16	317·43	·03
13	55·77	24·94	260·01	·20	77·89	34·83	355·46	398·00
18	55·32	24·70	197·21	·17	77·25	34·50	33·46	397·97
23	54·89	24·47	134·38	·13	76·65	34·17	71·43	·93
28	54·48	24·24	72·51	657·11	76·08	33·86	109·36	397·90
May 3	54·10	−24·02	8·62		75·55	−33·55	147·26	

Approximate Greenwich Mean Times of conjunctions of the satellites with the centre of the planet.

"n" inferior conjunction with centre, or satellite exactly in the direction of the minor axis of the ring, north, moving from the following to the preceding side.

"s" superior conjunction, or satellite south, moving from the preceding to the following side.

A few conjunctions of *Saturn* with stars are also given, of which those of Dec. 9 and Jan. 9 deserve specially to be watched. As the modern determinations of the star DM 22°1383 are at present not available, and its adopted apparent place for Dec. 9 $6^h\ 27^m\ 6^s{\cdot}04 + 22°\ 25'\ 23''{\cdot}4$ depends upon Ll. 12536, it is doubtful whether the star may not be occulted by the ring. It would be well if the corrections of the star's place, as also of the place of *Saturn*, were ascertained some time beforehand. The predicted conjunctions refer in this case, as in that of μ *Geminorum* on Jan. 9, to the axes of the ring.

1885.	h			1885.	h			1885.	h		
Sept. 15	1·2	Rh.	n.	Sept. 19	14·2	Te.	s.	Sept. 22	9·8	En.	s.
	1·3	Di.	s.		16·0	En.	s.		10·1	Te.	n.
	19·5	Te.	s.	20	12·7	Di.	s.	23	6·4	Di.	s.
16	10·1	Di.	n.		12·8	Te.	n.		8·8	Te.	s.
	18·2	Te.	n.		21·0 or 22·9				18·7	En.	s.
17	7·5	Rh.	s.		δ with $*\ 8^m{\cdot}8$			24	2·2	Rh.	n.
	16·8	Te.	s.		$*\ 58''$ south.				7·4	Te.	n.
	19·0	Di.	s.	21	11·5	Te.	s.		11·1	En.	n.
18	15·5	Te.	n.		17·4	En.	n.		15·2	Di.	n.
19	3·8	Di.	n.		20·0	Rh.	s.	25	6·1	Te.	s.
	13·7	Rh.	n.		21·5	Di.	n.		20·0	En.	n.

1885.	h		
Sept. 26	0·1	Di.	s.
	4·8	Te.	n.
	8·5	Rh.	s.
	12·5	En.	s.
27	3·4	Te.	s.
	9·0	Di.	n.
	21·4	En.	s.
28	2·2	Te.	n.
	13·8	En.	n.
	14·7	Rh.	n.
	17·8	Di.	s.
29	0·7	Te.	s.
	22·7	En.	n.
	23·4	Te.	n.
30	2·7	Di.	n.
	15·1	En.	s.
	20·9	Rh.	s.
	22·0	Te.	s.
Oct. 1	11·5	Di.	s.
	20·7	Te.	n.
2	16·5	En.	n.
	19·4	Te.	s.
	20·4	Di.	n.
3	3·1	Rh.	n.
	8·9	En.	s.
	18·0	Te.	n.
4	5·2	Di.	s.
	16·7	Te.	s.
	17·8	En.	s.
	21·4	Mi.	s.
5	9·4	Rh.	s.
	10·2	En.	n.
	14·0	Di.	n.
	15·3	Te.	n.
	20·0	Mi.	s.
6	14·0	Te.	s.
	18·6	Mi.	s.
	19·1	En.	n.
	22·9	Di.	s.
7	11·6	En.	s.

1885.	h		
Oct. 7	12·6	Te.	n.
	15·6	Rh.	n.
	17·2	Mi.	s.
8	7·7	Di.	n.
	11·3	Te.	s.
	15·9	Mi.	s.
	20·5	En.	s.
9	9·9	Te.	n.
	12·9	En.	n.
	14·5	Mi.	s.
	16·6	Di.	s.
	21·8	Rh.	s.
10	8·6	Te.	s.
	13·1	Mi.	s.
	21·8	En.	n.
11	1·4	Di.	n.
	7·2	Te.	n.
	11·7	Mi.	s.
	14·2	En.	s.
12	4·0	Rh.	n.
	5·9	Te.	s.
	10·3	Di.	s.
	21·6	Mi.	n.
	23·1	En.	s.
13	4·5	Te.	n.
	15·6	En.	n.
	19·1	Di.	n.
	20·3	Mi.	n.
14	3·2	Te.	s.
	10·3	Rh.	s.
	18·9	Mi.	n.
15	1·9	Te.	n.
	4·0	Di.	s.
	16·9	En.	s.
	17·5	Mi.	n.
16	0·5	Te.	s.
	9·3	En.	n.
	12·8	Di.	n.
	16·1	Mi.	n.
	16·5	Rh.	n.

1885.	h		
Oct. 16	23·2	Te.	n.
17	14·7	Mi.	n.
	18·2	En.	n.
	21·6	Di.	s.
	21·8	Te.	s.
18	10·6	En.	s.
	13·3	Mi.	n.
	20·5	Te.	n.
	22·7	Rh.	s.
19	6·5	Di.	n.
	12·0	Mi.	n.
	19·1	Te.	s.
	19·5	En.	s.
20	12·0	En.	n.
	15·3	Di.	s.
	17·8	Te.	n.
	21·9	Mi.	s.
21	4·9	Rh.	n.
	16·4	Te.	s.
	20·5	Mi.	s.
	20·8	En.	n.
22	0·2	Di.	n.
	13·3	En.	s.
	15·1	Te.	n.
	19·1	Mi.	s.
23	9·0	Di.	s.
	11·1	Rh.	s.
	13·7	Te.	s.
	17·7	Mi.	s.
	22·2	En.	s.
24	12·4	Te.	n.
	14·6	En.	n.
	16·3	Mi.	s.
	17·8	Di.	n.
25	11·0	Te.	s.
	15·0	Mi.	s.
	17·3	Rh.	n.
	23·5	En.	n.
26	2·6	Di.	s.
	9·7	Te.	n.

1885.	h		
Oct. 27	8·3	Te.	s.
	11·5	Di.	n.
	23·5	Rh.	s.
28	7·0	Te.	n.
	20·3	Di.	s.
29	5·6	Te.	s.
30	4·3	Te.	n.
	5·2	Di.	n.
	5·7	Rh.	n.
	18·6	En.	s.
	19·3	Mi.	n
31	2·9	Te.	s.
	11·0	En.	n.
	14·0	Di.	s.
	18·0	Mi.	n.
Nov. 1	1·6	Te.	n.
	11·9	Rh.	s.
	16·6	Mi.	n.
	19·9	En.	n.
	22·9	Di.	n.
2	0·22	Te.	s.
	12·3	En.	s.
	15·2	Mi.	n.
	22·9	Te.	n.
3	7·7	Di.	s.
	13·8	Mi.	n.
	18·0	Rh.	n.
	21·2	En.	s.
	21·5	Te.	s.
4	12·4	Mi.	n.
	13·7	En.	n.
	16·5	Di.	n.
	20·2	Te.	n.
5	6·1	En.	s.
	11·0	Mi.	n.
	18·8	Te.	s.
6	0·2	Rh.	s.
	1·4	Di.	s.
	15·0	En.	s.
	17·5	Te.	n.

1885.	h		
Nov. 6	21·0	Mi.	s.
7	7·4	En.	n.
	10·2	Di.	n.
	16·1	Te.	s.
	19·6	Mi.	s.
8	6·4	Rh.	n.
	14·8	Te.	n.
	16·3	En.	n.
	18·2	Mi.	s.
	19·0	Di.	s.
9	8·7	En.	s.
	13·4	Te.	s.
	16·8	Mi.	s.
10	3·8	Di.	n.
	12·0	Te.	n.
	12·6	Rh.	s.
	15·4	Mi.	s.
	17·6	En.	s.
11	10·0	En.	n.
	10·7	Te.	s.
	12·7	Di.	s.
	14·0	Mi.	s.
12	9·3	Te.	n.
	12·6	Mi.	s.
	18·8	Rh.	n.
	18·9	En.	n.
	21·5	Di.	n.
13	8·0	Te.	s.
	11·3	Mi.	s.
	11·4	En.	s.
14	6·3	Di.	s.
	6·6	Te.	n.
	9·9	Mi.	s.
	20·2	En.	s.
15	0·9	Rh.	s.
	5·3	Te.	s.
	12·7	En.	n.
	15·2	Di.	n.
	19·8	Mi.	n.
16	3·9	Te.	n.

1885.	h		
Nov. 16	18·4	Mi.	n.
	21·5	En.	n.
17	0·0	Di.	s.
	2·6	Te.	s.
	7·1	Rh.	n.
	14·0	En.	s.
	17·0	Mi.	n.
18	1·2	Te.	n.
	2·4 or 4·3		
	δ with $*$ $8^m{\cdot}8$		
	$*$ 62″ south.		
	6·4	En.	n.
	8·8	Di.	n.
	15·6	Mi.	n.
	23·9	Te.	s.
19	13·3	Rh.	s.
	14·2	Mi.	n.
	15·3	En.	n.
	17·6	Di.	s.
	22·5	Te.	n.
20	7·7	En.	s.
	12·9	Mi.	n.
	21·2	Te.	s.
21	2·5	Di.	n.
	19·4	Rh.	n.
	19·8	Te.	n.
22	11·3	Di.	s.
	18·4	Te.	s.
23	17·1	Te.	n.
	20·1	Di.	n.
24	1·6	Rh.	s.
	15·7	Te.	s.
25	4·9	Di.	s.
	14·4	Te.	n.
26	7·8	Rh.	n.
	11·7	En.	n.
	13·0	Te.	s.
	13·8	Di.	n.
	15·8	Mi.	s.
27	11·7	Te.	n.

1885.	h		
Nov. 27	14·4	Mi.	s.
	20·6	En.	n.
	22·6	Di.	s.
28	10·3	Te.	s.
	13·0	En.	s.
	13·1	Mi.	s.
	13·9	Rh.	s.
29	5·4	En.	n.
	7·4	Di.	n.
	9·0	Te.	n.
	11·7	Mi.	s.
30	7·6	Te.	s.
	10·3	Mi.	s.
	14·3	En.	n.
	16·2	Di.	s.
	20·1	Rh.	n.
Dec. 1	6·2	Te.	n.
	6·7	En.	s.
	8·9	Mi.	s.
2	1·1	Di.	n.
	4·9	Te.	s.
	7·5	Mi.	s.
	15·6	En.	s.
3	2·2	Rh.	s.
	3·5	Te.	n.
	8·1	En.	n.
	9·9	Di.	s.
	17·4	Mi.	n.
4	2·2	Te.	s.
	16·0	Mi.	n.
	16·9	En.	n.
	18·7	Di.	n.
5	0·8	Te.	n.
	8·4	Rh.	n.
	9·4	En.	s.
	14·7	Mi.	n.
	23·5	Te.	s.
6	3·5	Di.	s.
	13·3	Mi.	n.
	18·2	En.	s.

1885.	h		
Dec. 6	22·1	Te.	n.
7	10·7	En.	n.
	11·9	Mi.	n.
	12·3	Di.	n.
	14·5	Rh.	s.
	20·7	Te.	s.
8	10·5	Mi.	n.
	19·4	Te.	n.
	19·5	En.	n.
	21·2	Di.	s.
9	4·4	♂ of	
	✱ $8^m{\cdot}7$ with prec.		
	edge of ring		
	$y = -8''{\cdot}0$		
	6·4	♂ of ✱	
	with centre		
	$y = -12''{\cdot}2$		
	8·5	♂ of ✱	
	with foll. edge		
	$y = -16''{\cdot}4$		
	9·1	Mi.	n.
	12·0	En.	s.
	18·0	Te.	s.
	20·7	Rh.	n.
10	4·4	En.	n.
	6·0	Di.	n.
	7·7	Mi.	n.
	16·7	Te.	n.
11	13·3	En.	n.
	14·8	Di.	s.
	15·3	Te.	s.
	17·6	Mi.	s.
12	2·9	Rh.	s.
	5·7	En.	s.
	14·0	Te.	n.
	16·3	Mi.	s.
	23·6	Di.	n.
13	12·6	Te.	s.
	14·6	En.	s.
	14·9	Mi.	s.

1885.	h		
Dec. 14	7·0	En.	n.
	8·5	Di.	s.
	9·0	Rh.	n.
	11·2	Te.	n.
	13·5	Mi.	s.
15	9·9	Te.	s.
	12·1	Mi.	s.
	15·9	En.	n.
	17·3	Di.	n.
16	8·4	En.	s.
	8·5	Te.	n.
	10·7	Mi.	s.
	15·2	Rh.	s.
17	2·1	Di.	s.
	7·2	Te.	s.
	9·3	Mi.	s.
	17·2	En.	s.
18	5·8	Te.	n.
	10·9	Di.	n.
	21·3	Rh.	n.
19	4·5	Te.	s.
	18·5	En.	n.
	19·7	Di.	s.
20	3·1	Te.	n.
	11·0	En.	s.
21	1·7	Te.	s.
	3·5	Rh.	s.
	4·6	Di.	n.
22	0·4	Te.	n.
	13·4	Di.	s.
	23·0	Te.	s.
23	9·6	Rh.	n.
	21·7	Te.	n.
	22·2	Di.	n.
24	10·9	Mi.	n.
	13·6	En.	s
	20·3	Te.	s.
25	6·0	En.	n.
	7·0	Di.	s.
	9·5	Mi.	n.

1885.	h		
Dec.	25	15·7	Rh. s.
		19·0	Te. n.
	26	8·1	Mi. n.
		14·9	En. n.
		15·8	Di. n.
		17·6	Te. s.
	27	6·8	Mi. n.
		7·3	En. s.
		16·2	Te. n.
		21·9	Rh. n.
	28	0·7	Di. s.
		14·9	Te. s.
		16·2	En. s.
		16·7	Mi. s.
	29	8·7	En. n.
		9·5	Di. n.
		13·5	Te. n.
		15·3	Mi. s.
	30	4·0	Rh. s.
		12·2	Te. s.
		13·9	Mi. s.
		17·5	En. n.
		18·3	Di. s.
	31	10·0	En. s.
		10·8	Te. n.
		12·5	Mi. s.
1886.			
Jan.	1	2·4	En. n.
		3·1	Di. n.
		9·5	Te. s.
		10·2	Rh. n.
		11·1	Mi. s.
		18·8	En. s.
	2	6·2	δ of $*$
		$7^m·5$	$*$ 90″ south
		8·1	Te. n.
		9·7	Mi. s.
		11·3	En. n.
		11·9	Di. s.
		3·7	En. s.

1886.	h		
Jan.	3	6·7	Te. s.
		8·4	Mi. s.
		16·3	Rh. s.
		20·8	Di. n.
	4	5·4	Te. n.
		7·0	Mi. s.
		12·6	En. s.
	5	4·0	Te. s.
		5·6	Di. s.
		16·9	Mi. n.
		21·5	En. s.
		22·5	Rh. n.
	6	2·7	Te. n.
		13·9	En. n.
		14·4	Di. n.
		15·5	Mi. n.
	7	1·3	Te. s.
		6·3	En. s.
		14·1	Mi. n.
		23·2	Di. s.
	8	0·0	Te. n.
		4·6	Rh. s.
		12·7	Mi. n.
		15·2	En. s.
		22·6	Te. s.
	9	7·7	En. n.
		8·1	Di. n.
		11·3	Mi. n.
		18·6	δ of μ
		Gem. w. prec.	
		edge of ring,	
		$y = -22''·3$	
		20·7	δ w.
		centre $y = -26''·5$	
		21·3	Te. n.
		22·7	δ of μ
		Gem. w. foll. edge	
		$y = -30''·4$	
	10	10·0	Mi. n.
		10·8	Rh. n.

1886.	h		
Jan.	10	16·5	En. n.
		16·9	Di. s.
		19·9	Te. s.
	11	8·6	Mi. n.
		9·0	En. s.
		18·5	Te. n.
	12	1·7	Di. n.
		7·2	Mi. n.
		16·5	δ of $*$
		$8^m·8$	$*$ 92″ north
		17·0	Rh. s.
		17·2	Te. s.
		17·8	En. s.
	13	5·8	Mi. n.
		10·3	En. n.
		10·5	Di. s.
		15·8	Te. n.
		17·1	Mi. s.
	14	14·5	Te. s.
		15·7	Mi. s.
		19·2	En. n.
		19·3	Di. n.
		23·1	Rh. n.
	15	11·6	En. s.
		13·1	Te. n.
		14·3	Mi. s.
	16	4·2	Di. s.
		11·8	Te. s.
	17	5·3	Rh. s.
		10·4	Te. n.
		13·0	Di. n.
	18	9·1	Te. s.
		21·8	Di. s.
	19	7·7	Te. n.
		11·4	Rh. n.
	20	6·3	Te. s.
		6·6	Di. n.
	21	5·0	Te. n.
		15·5	Di. s.
		15·5	En. n.

1886.	h		
Jan.	21	17·3	Mi. n.
		17·6	Rh. s.
	22	3·6	Te. s.
		8·0	En. s.
		15·9	Mi. n.
	23	0·3	Di. n.
		2·3	Te. n.
		14·6	Mi. n.
		16·9	En. s.
		23·8	Rh. n.
	24	0·9	Te. s.
		9·1	Di. s.
		9·3	En. n.
		13·2	Mi. n.
		23·6	Te. n.
	25	11·8	Mi. n.
		18·0	Di. n.
		18·2	En. n.
		22·2	Te. s.
	26	5·9	Rh. s.
		10·4	Mi. n.
		10·6	En. s.
		20·9	Te. n.
	27	2·8	Di. s.
		3·1	En. n.
		9·0	Mi. n.
		19·5	En. s.
		19·5	Te. s.
	28	7·6	Mi. n.
		11·6	Di. n.
		11·9	En. n.
		12·1	Rh. n.
		18·2	Te. n.
	29	4·4	En. s.
		6·3	Mi. n.
		16·8	Te. s.
		20·4	Di. s.
	30	4·9	Mi. n.
		13·3	En. s.
		15·5	Te. n.

1886.	h		
Jan.	30	16·2	Mi. s.
		18·3	Rh. s.
	31	5·3	Di. n.
		5·7	En. n.
		14·1	Te. s.
		14·8	Mi. s.
Feb.	1	12·8	Te. n.
		13·4	Mi. s.
		14·1	Di. s.
		14·6	En. n.
	2	0·4	Rh. n.
		7·0	En. s.
		11·4	Te. s.
		12·0	Mi. s.
		22·9	Di. n.
	3	10·1	Te. n.
		10·6	Mi. s.
		15·9	En. s.
	4	6·6	Rh. s.
		7·8	Di. s.
		8·3	En. n.
		8·7	Te. s.
		9·3	Mi. s.
	5	0·8	En. s.
		7·4	Te. n.
		7·9	Mi. s.
		16·6	Di. n.
		17·2	En. n.
	6	6·0	Te. s.
		6·5	Mi. s.
		9·7	En. s.
		12·8	Rh. n.
	7	1·4	Di. s.
		2·1	En. n.
		4·7	Te. n.
		5·1	Mi. s.
	8	3·3	Te. s.
		10·3	Di. n.
		11·0	En. n.
		15·0	Mi. n.

1886.	h		
Feb.	8	19·0	Rh. s.
	9	2·0	Te. n.
		3·4	En. s.
		13·7	Mi. n.
		19·1	Di. s.
	10	0·6	Te. s.
		12·3	Mi. n.
		12·3	En. s.
		23·3	Te. n.
	11	1·2	Rh. n.
		3·9	Di. n.
		4·7	En. n.
		10·9	Mi. n.
		21·2	En. s.
		21·9	Te. s.
	12	9·5	Mi. n.
		12·8	Di. s.
		13·6	En. n.
		20·6	Te. n.
	13	6·1	En. s.
		7·4	Rh. s.
		8·1	Mi. n.
		19·2	Te. s.
		21·6	Di. n.
	14	17·9	Te. n.
	15	6·4	Di. s.
		7·4	En. n.
		13·5	Rh. n.
		16·5	Te. s.
	16	15·2	Te. n.
		15·3	Di. n.
		15·3	Mi. s.
		16·3	En. n.
	17	8·7	En. s.
		13·8	Te. s.
		13·9	Mi. s.
		19·7	Rh. s.
	18	0·1	Di. s.
		12·5	Te. n.
		12·5	Mi. s.

1886.	h		
Feb. 18	17·6	En.	s.
19	9·0	Di.	n.
	10·0	En.	n.
	11·1	Te.	s.
	11·1	Mi.	s.
20	1·9	Rh.	n.
	2·5	En.	s.
	9·8	Mi.	s.
	9·8	Te.	n.
	17·8	Di.	s.
21	8·4	Mi.	s.
	8·4	Te.	s.
	11·4	En.	s.
22	2·6	Di.	n.
	3·8	En.	n.
	7·0	Mi.	s.
	7·1	Te.	n.
	8·1	Rh.	s.
23	5·6	Mi.	s.
	5·7	Te.	s.
	11·5	Di.	s.
	12·7	En.	n.
24	4·2	Mi.	s.
	4·4	Te.	n.
	5·1	En.	s.
	14·3	Rh.	n.
	15·5	Mi.	n.
	20·3	Di.	n.
25	3·0	Te.	s.
	14·0	En.	s.
	14·2	Mi.	n.
26	1·7	Te.	n.
	5·2	Di.	s.
	6·5	En.	n.
	12·8	Mi.	n.
	20·5	Rh.	s.
27	0·3	Te.	s.
	11·4	Mi.	n.
	14·0	Di.	n.
	15·4	En.	n.

1886.	h		
Feb. 27	23·0	Te.	n.
28	7·8	En.	s.
	10·0	Mi.	n.
	21·7	Te.	s.
	22·9	Di.	s.
Mar. 1	2·8	Rh.	n.
	8·6	Mi.	n.
	16·7	En.	s.
	20·3	Te.	n.
2	7·3	Mi.	n.
	7·7	Di.	n.
	9·1	En.	n.
	19·0	Te.	s.
3	1·6	En.	s.
	5·9	Mi.	n.
	9·0	Rh.	s.
	16·5	Di.	s.
	17·6	Te.	n.
4	4·5	Mi.	n.
	10·5	En.	s.
	15·8	Mi.	s.
	16·3	Te.	s.
5	1·4	Di.	n.
	2·9	En.	n.
	14·4	Mi.	s.
	14·9	Te.	n.
	15·2	Rh.	n.
6	10·2	Di.	s.
	11·8	En.	n.
	13·1	Mi.	s.
	13·6	Te.	s.
7	4·2	En.	s.
	11·7	Mi.	s.
	12·3	Te.	n.
	19·1	Di.	n.
	21·4	Rh.	s.
8	10·3	Mi.	s.
	10·9	Te.	s.
	13·1	En.	s.
9	3·9	Di.	s.

1886.	h		
Mar. 9	5·6	En.	n.
	8·9	Mi.	s.
	9·6	Te.	n.
10	3·6	Rh.	n.
	7·5	Mi.	s.
	8·2	Te.	n.
	12·8	Di.	n.
	14·5	En.	n.
11	6·2	Mi.	s.
	6·9	Te.	n.
	6·9	En.	s.
	21·6	Di.	s.
12	5·5	Te.	s.
	9·9	Rh.	s.
13	4·2	Te.	n.
	6·5	Di.	n.
	8·3	En.	n.
14	2·9	Te.	s.
	15·3	Di.	s.
	16·1	Rh.	n.
15	1·5	Te.	n.
	9·6	En.	s.
	12·0	Mi.	n.
16	0·2	Te.	s.
	0·2	Di.	n.
	2·0	En.	n.
	10·6	Mi.	n.
	22·3	Rh.	s.
	22·8	Te.	n.
17	9·0	Di.	s.
	9·2	Mi.	n.
	10·9	En.	n.
	21·5	Te.	s.
18	3·4	En.	s.
	7·8	Mi.	n.
	17·9	Di.	n.
	20·2	Te.	n
19	4·6	Rh.	n
	18·8	Te.	s.
20	2·8	Di.	s.

1886.	h		
Mar. 20	17·5	Te.	n.
21	10·8	Rh.	s.
	11·6	Di.	n.
	13·6	En.	n.
	16·1	Te.	s.
22	6·1	En.	s.
	13·6	Mi.	s.
	14·8	Te.	n.
	20·5	Di.	s.
23	12·3	Mi.	s.
	13·5	Te.	s.
	15·0	En.	s.
	17·0	Rh.	n.
24	5·3	Di.	n.
	7·4	En.	n.
	10·9	Mi.	s.
	12·1	Te.	n.
25	9·5	Mi.	s.
	10·8	Te.	s.
	14·2	Di.	s.
	23·3	Rh.	s.
26	8·1	Mi.	s.
	8·7	En.	s.
	9·4	Te.	n.
	23·0	Di.	n.
27	1·2	En.	n.
	6·7	Mi.	s.
	8·1	Te.	s.
28	5·5	Rh.	n.
	6·8	Te.	n.
	7·9	Di.	s.
	10·1	En.	n.
29	5·4	Te.	s.
	16·8	Di.	n.
30	4·1	Te.	n.
	11·4	En.	s.
	11·8	Rh.	s.
	13·9	Mi.	n.

1886.	h		
Mar. 31	1·6	Di.	s.
	2·7	Te.	s.
	3·9	En.	n.
	12·6	Mi.	n.
Apr. 1	1·4	Te.	n.
	10·5	Di.	n.
	11·2	Mi.	n.
	12·8	En.	n.
	18·1	Rh.	n.
2	0·1	Te.	s.
	5·3	En.	s.
	9·8	Mi.	n.
	19·3	Di.	s.
	22·7	Te.	n.
3	8·4	Mi.	n.
	14·2	En.	s.
	21·4	Te.	s.
4	0·3	Rh.	s.
	4·2	Di.	n.
	6·7	En.	n.
	20·1	Te.	n.
5	13·1	Di.	s.
	15·5	En.	n.
	18·7	Te.	s.
6	6·6	Rh.	n.
	7·9	En.	s.
	17·4	Te.	n.
	21·9	Di.	n.
7	16·1	Te.	s.
8	6·8	Di.	s.
	9·2	En.	n.
	12·8	Rh.	s.
	14·7	Te.	n.
9	13·4	Te.	s.
	15·7	Di.	n.
10	10·6	En.	s.
	12·0	Te.	n.

1886.	h		
Apr. 10	19·1	Rh.	n.
11	0·5	Di.	s.
	10·7	Te.	s.
12	9·4	Te.	n.
	9·4	Di.	n.
13	1·4	Rh.	s.
	8·0	Te.	s.
	18·3	Di.	s.
14	6·7	Te.	n.
15	3·1	Di.	n.
	5·4	Te.	s.
	7·6	Rh.	n.
16	4·0	Te.	n.
	12·0	Di.	s.
17	2·7	Te.	s.
	13·9	Rh.	s.
	20·9	Di.	n.
18	1·4	Te.	n.
19	0·0	Te.	s.
	5·7	Di.	s.
	20·2	Rh.	n.
	22·7	Te.	n.
20	14·9	Di.	n.
	21·4	Te.	s
21	20·0	Te.	n.
	23·5	Di.	s.
22	2·5	Rh.	s.
	18·7	Te.	s.
23	8·3	Di.	n.
	17·4	Te.	n.
24	8·7	Rh.	n.
	16·0	Te.	s.
	17·2	Di.	s.
25	14·7	Te.	n.
26	2·1	Di.	n.
	13·4	Te.	s.
	15·0	Rh.	s

By means of this list of conjunctions, approximate values of the coordinates x and y, expressed in semi-diameters of the planet's equator, may be easily found for any other time t in the following little table, the argument of which is the interval τ between the time t and the time of the nearest preceding or following conjunction.

τ	*Mimas.*		*Enceladus.*		*Tethys.*		*Dione.*		*Rhea.*	
h	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	x_5	y_5
0	0·0	1·4	0·0	1·8	0·0	2·3	0·0	2·9	0·0	4·0
1	0·9	1·4	0·8	1·7	0·7	2·2	0·6	2·9	0·5	4·0
2	1·7	1·2	1·5	1·7	1·4	2·2	1·2	2·8	1·0	4·0
3	2·3	0·9	2·2	1·5	2·0	2·1	1·8	2·8	1·5	4·0
4	2·8	0·6	2·8	1·3	2·6	1·9	2·4	2·7	2·0	3·9
5	3·1	0·3	3·3	1·0	3·2	1·7	2·9	2·6	2·5	3·8
6	3·1	0·1	3·7	0·7	3·7	1·5	3·5	2·4	3·0	3·8
7	2·9	0·5	3·9	0·4	4·1	1·3	4·0	2·3	3·5	3·7
8	2 5	0·9	4·0	0·1	4·5	1·0	4·4	2·1	4·0	3·6
9					4·7	0·7	4·8	1·9	4·5	3·5
10					4·9	0·4	5·2	1·7	4·9	3·4
11					5·0	0·1	5·6	1·4	5·3	3·2
12							5·8	1·2	5·7	3·1
13							6·1	0·9	6·1	2·9
14							6·2	0·7	6·5	2·8
15							6·3	0·4	6·8	2·6
16							6·4	0·1	7·1	2·4
20									8·2	1·6
27·1									8·9	0·0

The satellites move in the direction of *de*creasing position-angles. They are at their greatest elongations, Mi. $5^h{\cdot}7$, En. $8^h{\cdot}2$, Te. $11^h{\cdot}3$, Di. $16^h{\cdot}4$, Rh. $27^h{\cdot}1$, before or after the times of conjunction. Observers who are desirous to follow the motions of the satellites will do well to lay down the data of the table graphically on a sufficiently large scale, so that, by marking the corresponding times for the night of observing, they may get information about the places of the satellites at a glance.

Differences of Right Ascension and Declination between the three outer Satellites and the Centre of Saturn.

		Titan.		*Hyperion.*		*Iapetus.*	
0^h Gr. 1885.		α_6-A s	δ_6-D "	α_7-A s	δ_7-D "	α_8-A s	δ_8-D "
Sept	15	+ 8·50	− 50·2	− 9·92	− 83·4	+27.01	− 19·0
	16	+11.63	− 22·8	− 6·25	− 95·9	29·09	− 8·1
	17	+13·06	+ 8·0	− 2·04	−100·5	+31·00	+ 2·8
	18	+12·50	+ 37·7	+ 2·34	− 97·5	32·75	13·8
	19	+ 9·98	+ 61·5	+ 6·57	− 87·7	+34·32	+ 24·7
	20	+ 5·82	+ 75·4	+10·40	− 72·1	35·70	35·5
	21	+ 0·69	+ 76·8	+13·58	− 51·8	+36·89	+ 46·1
	22	− 4·58	+ 65·5	+15·93	− 28·3	37·88	56·5
	23	− 9·11	+ 43·2	+17·31	− 3·0	+38·66	+ 66·6
	24	−12·18	+ 13·9	+17·59	+ 22·6	38·22	76·4
	25	−13·35	− 17·8	+16·71	+ 46·7	+39·56	+ 85·7
	26	−12·49	− 46·8	+14·63	+ 67·6	39·68	94·5
	27	− 9·78	− 69·1	+11·41	+ 83·3	+39·58	+102·9
	28	− 5·65	− 81·5	+ 7·21	+ 91·9	39·25	110·7
	29	− 0·72	− 82·4	+ 2·31	+ 91·7	+38·70	+117·9
	30	+ 4·34	− 71·8	− 2·84	+ 81·9	37·92	124·5
Oct.	1	+ 8·81	− 50·9	− 7·68	+ 62·6	+36·93	+130·3
	2	+12·01	− 22·6	−11·59	+ 35·5	35·72	135·4
	3	+13·44	+ 9·1	−14·06	+ 3·8	+34·29	+139·8
	4	+12·82	+ 39·5	−14·81	− 28·4	32·66	143·4
	5	+10·17	+ 63·7	−13·85	− 57·5	+30·83	+146·1
	6	+ 5·85	+ 77·6	−11·42	− 80·7	28·81	147·9
	7	+ 0·55	+ 78·7	− 7·90	− 96·3	+26·60	+148·9
	8	− 4·87	+ 66·6	− 3·67	−103·7	24·23	149·1
	9	− 9·50	+ 43·3	+ 0·85	−103·1	+21·71	+148·3
	10	−12·61	+ 13·1	+ 5·34	− 95·1	19·04	146·6
	11	−13·75	− 19·4	+ 9·49	− 80·8	+16·24	+144·1
	12	−12·79	− 49·1	+13·05	− 61·3	13·33	140·6
	13	− 9·95	− 71·7	+15·81	− 37·9	+10·33	+136·2
	14	− 5·65	− 84·0	+17·60	− 12·0	7·25	131·0
	15	− 0·54	− 84·5	+18·28	+ 14·7	+ 4·11	+125·0
	16	+ 4·66	− 73·0	+17·76	+ 40·5	+ 0·93	118·2
	17	+ 9·23	− 51·2	+15·99	+ 63·6	− 2·26	+110·5
	18	+12·47	− 21·8	+12·98	+ 81·8	5·46	102·1
	19	+13·86	+ 10·9	+ 8·88	+ 93·2	− 8·64	+ 93·0
	20	+13·12	+ 42·0	+ 3·93	+ 96·0	11·77	83·3
	21	+10·30	+ 66·5	− 1·43	+ 88·7	−14·84	+ 73·0

		Titan.		*Hyperion.*		*Iapetus.*	
0^h Gr. 1885.		α_6—A	δ_6—D	α_7—A	α_7—D	α_8—A	δ_8—D
		s	"	s	"	s	"
Oct.	22	+ 5·80	+ 80·2	− 6·64	+ 71·3	17·81	62·2
	23	+ 0·29	+ 80·6	−11·06	+ 15·1	−20·67	+ 50·9
	24	− 5·28	+ 67·5	−14·09	+ 13·2	23·41	39·2
	25	− 9·99	+ 43·2	−15·38	− 20·5	−26·01	+ 27·2
	26	−13·10	+ 11·7	−14·87	− 52·0	28·44	15·0
	27	−14·15	− 21·8	−12·77	− 78·2	−30·69	+ 2·6
	28	−13·05	− 52·1	− 9·36	− 96·5	32·73	− 9·9
	29	−10·02	− 74·8	− 5·13	−106·6	−34·54	− 22·3
	30	− 5·52	− 86·8	− 0·48	−108·3	36·13	34·7
	31	− 0·23	− 86·6	+ 4·24	−102·1	−37·48	− 46·9
Nov.	1	+ 5·12	− 74·1	+ 8·68	− 89·0	38·57	58·8
	2	+ 9·77	− 51·0	+12·57	− 70·0	−39·39	− 70·3
	3	+12·98	− 20·4	+15·70	− 46·6	39·95	81·4
	4	+14·21	+ 13·3	+17·86	− 20·2	−40·24	− 92·0
	5	+13·36	+ 45·1	+18·89	+ 7·6	40·25	102·0
	6	+10·32	+ 69·7	+18·68	+ 34·9	−39·97	−111·4
	7	+ 5·57	+ 83·0	+17·17	+ 60·0	39·41	120·0
	8	− 0·12	+ 82·5	+14·36	+ 80·5	−38·57	−127·8
	9	− 5·81	+ 68·1	+10·36	+ 94·5	37·47	134·8
	10	−10·55	+ 42·3	+ 5·40	+ 99·8	−36·11	−141·0
	11	−13·60	+ 9·5	− 0·12	+ 94·9	34·50	146·2
	12	−14·52	− 24·9	− 5·63	+ 79·3	−32·64	−150·4
	13	−13·21	− 55·6	−10·47	+ 54·1	30·55	153·6
	14	− 9·95	− 78·3	−14·00	+ 22·0	−28·26	−155·8
	15	− 5·24	− 89·8	−15·79	− 13·0	25·77	157·0
	16	+ 0·23	− 88·5	−15·68	− 46·6	−23·09	−157·2
	17	+ 5·69	− 74·7	−13·83	− 75·2	20·25	156·3
	18	+10·34	− 50·1	−10·59	− 96·4	−17·28	−154·3
	19	+13·49	− 18·2	− 6·37	−109·0	14·18	151·3
	20	+14·59	+ 16·5	− 1·61	−112·8	−10·98	−147·4
	21	+13·49	+ 48·7	+ 3·28	−108·2	7·70	142·5
	22	+10·19	+ 73·2	+ 7·97	− 96·1	− 4·35	−136·6
	23	+ 5·21	+ 85·7	+12·14	− 77·6	− 0·97	129·8
	24	− 0·66	+ 83·9	+15·56	− 54·3	+ 2·42	−122·2
	25	− 6·43	+ 68·0	+18·02	− 27·4	5·81	113·8
	26	−11·15	+ 40·7	+19·33	+ 1·2	+ 9·18	−104·6
	27	−14·06	+ 6·7	+19·39	+ 29·9	12·49	94·7
	28	−14·83	− 28·5	+18·11	+ 56·6	+15·73	− 84·1
	29	−13·23	− 59·5	+15·48	+ 79·1	18·88	73·0
	30	− 9·72	− 81·8	+11·59	+ 95·2	+21·92	− 61·4
Dec.	1	− 4·79	− 92·3	+ 6·65	+102·8	+24·83	− 49·4

The rest will be published in the Supplementary Number.

Ephemeris of the Satellite of Neptune, 1885–86. By A. Marth.

P, angle of position of the minor axis of the satellite's apparent orbit, in the direction of superior conjunction.

a, *b*, major and minor semi-axis of the apparent orbit.

u−U, longitude of the satellite in its orbit, reckoned from the point which is in superior conjunction with the planet or in opposition to the Earth.

U + 180°, planetocentric longitude of the Earth, reckoned in the satellite's orbit from the ascending node on the celestial equator.

B, planetocentric latitude of the Earth above the plane of the satellite's orbit.

0^h Gr.	P	*a*	*b*	*u*−U	Diff.	U	B
1885.	°	″	″	°	°	°	°
Sept. 15	322·20	16·68	7·81	156·14	612·49	133·42	27·94
25	322·10	16·76	7·84	48·63	·44	133·55	27·90
Oct. 5	321·97	16·83	7·86	301·07	·39	133·73	27·84
15	321·80	16·89	7·87	193·46	·34	133·94	27·76
25	321·61	16·94	7·86	85·80	·31	134·19	27·66
Nov. 4	321·41	16·97	7·85	338·11	·29	134·47	27·55
14	321·19	16·98	7·82	230·40	·27	134·76	27·44
24	320·97	16·97	7·79	122·67	·28	135·04	27·32
Dec. 4	320·77	16·94	7·74	14·95	·29	135·32	27·20
14	320·58	16·90	7·69	267·24	·31	135·57	27·09
24	320·41	16·84	7·64	159·55	·34	135·80	26·99
1886.							
Jan. 3	320·27	16·77	7·59	51·89	612·39	135·98	26·90
13	320·17	16·69	7·54	304·28	·43	136·11	26·84
23	320·11	16·60	7·49	196·71	·49	136·19	26·79
Feb. 2	320·10	16·51	7·44	89·20	·55	136·21	26·77
12	320·12	16·41	7·40	341·75	·60	136·17	26·78
22	320·19	16·32	7·36	234·35	·66	136·07	26·81
Mar. 4	320·30	16·23	7·33	127·01	612·72	135·92	26·86
14	320·45	16·15	7·31	19·73		135·72	26·93

The values of P, *a*, *b*, and *u*−U are to be interpolated for the times for which the apparent positions of the satellite are required, and the position-angles *p* and distances *s* are then found by means of the equations

$$s \sin (P-p) = a \sin (u-U)$$
$$s \cos (P-p) = b \cos (u-U).$$

The satellite moves in the direction of decreasing position-angles, and will be at its greatest elongations and at its conjunctions with the planet at the following hours, Greenwich mean time.

	nf. Elong. $p=$ P+90° $s=$ *a*		*Sup.* Conj. P *b*		*sp.* Elong. P−90° *a*		*Inf.* Conj. P−180° *b*	
1885.		h		h		h		h
Sept.	16	20·6	Sept. 18	7·9	Sept. 19	19·1	Sept. 21	6·4
	22	17·7	24	4·9	25	16·2	27	3·5
	28	14·7	30	2·0	Oct. 1	13·3	Oct. 3	0·6
Oct.	4	11·8	Oct. 5	23·1	7	10·4	8	21·6
	10	8·9	11	20·2	13	7·4	14	18·7
	16	6·0	17	17·3	19	4·5	20	15·8
	22	3·1	23	14·4	25	1·6	26	12·9
	28	0·2	29	11·5	30	22·7	Nov. 1	10·0
Nov.	2	21·3	Nov. 4	8·6	Nov. 5	19·9	7	7·1
	8	18·4	10	5·7	11	17·0	13	4·2
	14	15·5	16	2·8	17	14·1	19	1·4
	20	12·6	21	23·9	23	11·2	24	22·5
	26	9·7	27	21·0	29	8·3	30	19·6
Dec.	2	6·9	Dec. 3	18·1	Dec. 5	5·4	Dec. 6	16·7
	8	4·0	9	15·2	11	2·5	12	13·8
	14	1·1	15	12·4	16	23·6	18	10·9
	19	22·2	21	9·5	22	20·7	24	8·0
	25	19·3	27	6·6	28	17·8	30	5·1
	31	16·4	Jan. 2	3·7	Jan. 3	14·9	Jan. 5	2·2
1886.								
Jan.	6	13·5	8	0·7	9	12·0	10	23·3
	12	10·6	13	21·8	15	9·1	16	20·4
	18	7·6	19	18·9	21	6·2	22	17·5
	24	4·7	25	16·0	27	3·2	28	14·5
	30	1·8	31	13·0	Feb. 2	0·3	Feb. 3	11·6
Feb.	4	22·8	Feb. 6	10·1	7	21·4	9	8·6
	10	19·9	12	7·1	13	18·4	15	5·7
	16	16·9	18	4·2	19	15·4	21	2·7
	22	14·0	24	1·2	25	12·5	26	23·7
	28	11·0	Mar. 1	22·2	Mar. 3	9·5	Mar. 4	20·8

Errata in Mr. Thackeray's paper on the Diameters of the Sun and Moon.

Page 391, lines 15, 11, and 9 from bottom, *for* 1853, 1854, and 1857, *read* 1854, 1855, and 1856.

„ 392, line 7, *for* 1877 till 1880, *read* 1878 till 1880.

„ 395, in sixth column under "Lynn," the mean annual values should be

1875	...	...	$-2''\cdot00_{20}$
1876	...	...	$-1\cdot14_{10}$
1877	...	...	$-1\cdot23_{9}$